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An evaluation of a tactical active multi-environment acoustic prediction system vs measured data

Coleman, Robert Eric

Monterey, California. Naval Postgraduate School

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AN EVALUATION OF A TACTICAL ACTIVE MULTI-ENVIRONMENT ACOUSTIC PREDICTION SYSTEM VS MEASURED DATA

by

Robert Eric Coleman
Lieutenant, United States Navy
B.S., United States Naval Academy, 1987

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ABSTRACT

This thesis evaluates the capabilities of MAPS (Multi-Environment AIM (Acoustic Interference Monitor) Prediction System) to determine if the system can accurately predict shallow water propagation loss. SHAREM 102 produced real world propagation loss data from the Gulf of Oman that was used to conduct comparison runs using MAPS. It was found that MAPS was an accurate, user friendly, tactical decision aid for littoral shallow water predictions.

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I. INTRODUCTION

This thesis will evaluate the use of a range dependent active propagation loss model in a slope water environment and compare the predictions against real world SHAREM exercise measurements from the Gulf of Oman. The range dependent propagation loss (PL) model is in MAPS (Multi-Environment AIM (Acoustic Interference Monitor) Prediction System. MAPS was developed to be part of a tactical AN/SQS-26/53 sonar system where ping-by-ping and beam-by-beam predictions can be made. Most active tactical propagation loss models in the fleet are range independent because the only environmental input data available is at own ship's position to input into the propagation loss model. Also most research range dependent propagation loss models are difficult to operate with respect to entry of environmental data. The bathymetry and the sound speed are highly variable in slope areas of the Gulf of Oman. MAPS utilizes an upgraded bathymetry for shallow water regions and has special capability to enter XBT profiles along the acoustic path in order to improve propagation loss predictions.

In January 1993, operational and scientific tests were conducted during SHAREM 102 sponsored by the Surface Warfare Development Group (SWDG). Active 3.5 kHz acoustic propagation loss was measured in two areas of the Gulf of Oman for several different slope conditions. Three surface ships were involved in the exercises: USNS Silas Bent, USS Stump (DD978), and USS Samuel B. Roberts (FFG58). Each of the ships involved in the exercises obtained XBT measurements at various times and locations along their tracks.

Two events in SHAREM 102, Events 08117 and 10115 were used to measure in-situ propagation loss at 25N 060E. Due to the quality of the data and the variability of the quantitative results, the Gulf of Oman measured propagation loss provides several excellent sets of measurements for evaluating a range dependent model.

Event 08117 on 8 January 1993 consisted of two runs (down and across the slope) in water depths from 500m to 750m. Up slope runs refer to the source ship, USS Stump with a SQS-53C, transmitting acoustic energy at 3.5 kHz up the slope to the receiving hydrophones on the drifting USS Samuel B. Roberts. The down slope runs consist of the source ship transmitting sound the slope to the receiving ship. Across slope consists of having the source and receiver ships on a line parallel to the slope transmitting acoustic energy across the slope. The first run was started at 500m water depth and proceeded to the 750m depth to obtain the down slope measurements. The second run measured the propagation loss data over a level bottom. The second run had a constant depth of 750m. Event 10115 was for three runs (up, down and across the slope) in water depths from 275m to 700m. The down slope run began at 275m and ended at 460m. The across slope was conducted at 460m. The final run was an up slope run and began with a 700m depth and concluded at 475m. In each run a set of propagation loss data was obtained.

For Event 10115 three hydrophones were utilized at depths of 25 ft, 60 ft and 300 ft for all three runs. For Event 08117 Run 1, only the 60 ft hydrophone was operating and in run 2, only the 25 ft and 60 ft hydrophones were available on the USS Samuel B. Roberts.

A propagation loss range plot was generated at each hydrophone depth for each run. A comparison between the propagation loss generated by MAPS and measured data is the basic purpose of the thesis. The impact of environmental data inputs such as bottom loss, bathymetry, and XBT locations on the generation of propagation loss is investigated. Finally the MAPS model/system is assessed as to its usefulness to an Anti-Submarine Warfare Commander for shallow water tactical decisions.

II. DESCRIPTION OF MAPS

A. INTRODUCTION TO MAPS

The Multi-environment AIM Prediction System (MAPS) is a real time range dependent expansion of the Navy's standard RAYMODE propagation loss model for active sonar. Range dependent RAYMODE is being developed by Dr. Leibiger and MAPS was developed by Steve Dasinger of The Naval Undersea Warfare Center, New London, Connecticut. MAPS was developed to accurately predict propagation loss in highly variable environments for use with the AN/SQS-26/53 sonar systems. It has the capability to continually update the environmental data bases for potential operational areas.

B. MAPS INPUT

MAPS begins with a query of own ship sonar parameters. This first set of queries includes updating own ship's speed and sonar sector center, own ship's heading and own ship's sonar characteristics. Information about sonar parameters such as source level, signal differential noise, signal differential reverberation, and own ship noise default to sonar self-measurements in the ship-installed version, but the user may alter these parameters if needed. Pulse length is another query which adds important information to increase the accuracy of the prediction. The last tactical information required is Target Strength. Once own ship data, is updated, the user updates the Environmental Input Data.

The Environmental Inputs Data is updated by entering a date/time and Lat/Long which begins the setup for proper data file extraction of

the historical data bases. The Lat/Long entry can be used in one of two ways. If the ship has XBT information from another ship along the track of interest then the Lat/Long will be the entry for the location of the obtained XBT information. Once all the XBT information from other sources has been entered, then the final XBT information is entered at own ship's position.

With the Lat/Long and date entry for own ship data, MAPS determines whether there is data in the historical data base to calculate propagation loss in the area of interest (AOI). The first display and part of the MAPS data base is the Marine Geographical Survey (MGS) bottom loss classification (Figure 1). In this

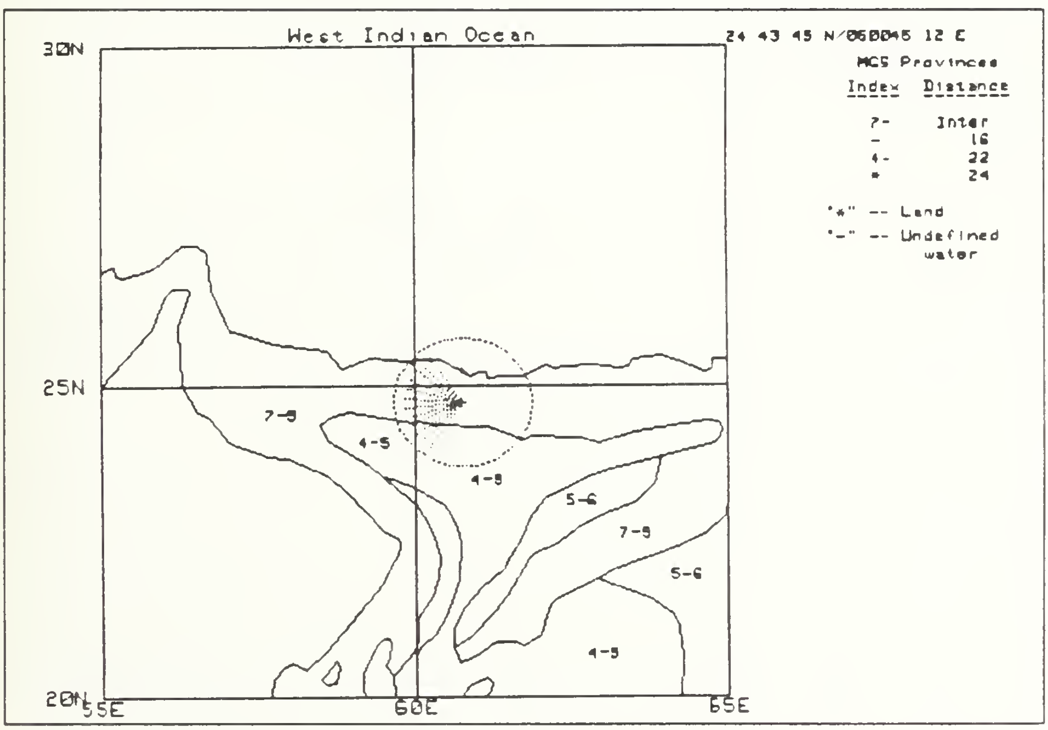


Figure 1. MGS Bottom Regions

data base the ocean bottom is categorized into nine bottom types. Region 1 is the most reflective and region 8 is the most absorbent. In MAPS region 9 is a special bottom loss input for MAPS that is

representative of the SHAREM areas in the Gulf of Oman. Both measurement areas evaluated in the Gulf of Oman use the Gulf of Oman bottom loss (region 9), which is for a low bottom loss as shown in Figure 2. This figure shows the curve for grazing angle Vs loss that is used in MAPS for propagation loss calculations. Initial attempts to use the standard data base value for MGS-7 bottom loss province resulted in unrealistic high propagation loss for the 60 ft hydrophone in Event 08117 runs 1 and 2. Because MGS-7 is a very high loss province, there is greater than 30 dB loss at 10 kyds and 60 dB or greater loss at 20 kyds compared to the measured data. These 60 ft prediction results for runs 1 and 2 are contained in Appendix A. As a result of this data the decision was made to only use the Gulf of Oman bottom loss data (region 9) as shown in Figure 2 for all MAPS predictions.

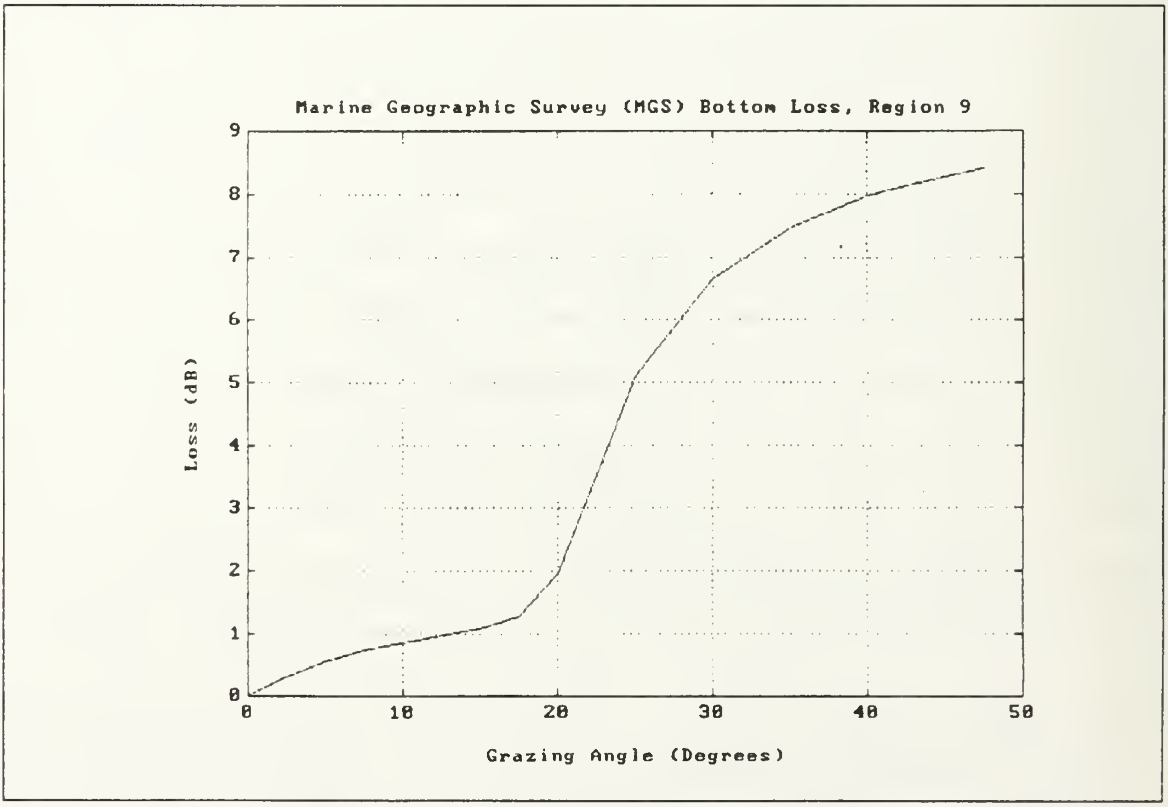


Figure 2. MGS Bottom Loss Curve for Region 9 (GOO)

The next major input is the sound speed profile (SSP). The SSP display, Figure 3, shows the user where historical regions of SSP's exist. The historical SSP areas are those used in the original SIMAS (UYQ-25) and currently in use by the CDC (Combat Data Collection) R&D program. If there is no SSP for the Lat/Long of interest, MAPS will

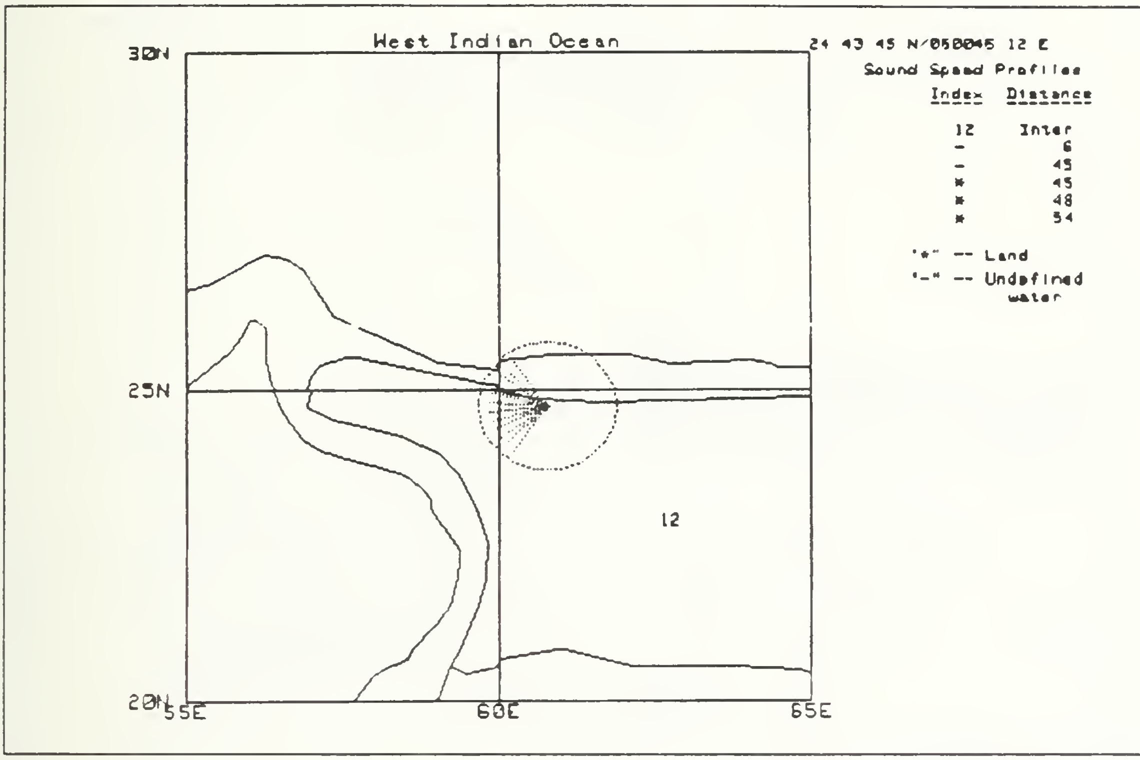


Figure 3. SSP Data Base Regions

prompt the user to enter in an entire XBT profile so that propagation loss calculations can be accomplished. The last environmental display shows the standard bathymetry boundaries in the area (Figure 4). The standard bathymetry is from depth contours from the original SIMAS, UYQ-25. The real advantage of MAPS is that it allows the user to insert many sound speed profiles in the area of interest.

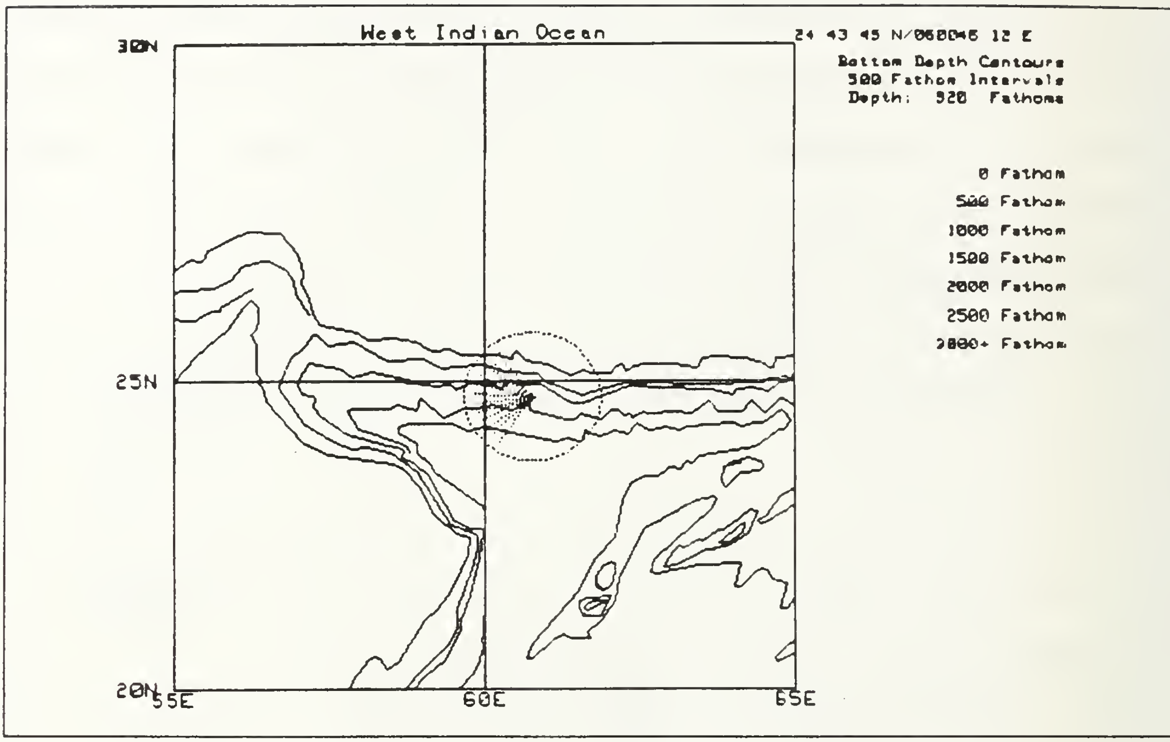


Figure 4. Standard Bottom Depth Contours

MAPS gives the user a choice of whether or not to use the SAAAB (Shallow Water APP (Acoustic Performance Prediction) And ASPR (Active Sonar Performance Realization) Bathymetry) data base. In the Gulf of Oman, SAAAB contains the latest Naval Oceanographic Office high resolution bathymetry which is used in the SIMAS-ADM. If the area of concern is shallow, then it is recommended that this high resolution bathymetry capability be utilized. Later it will be shown that there is a significant difference when selecting or not selecting the SAAAB capability in a shallow water area. A sample of the SAAAB high resolution bathymetry information is illustrated in Figure 5.

After the historical data is selected, the MAPS user selects the AOI ocean, inserts wind speed, and selects day or night to determine biological scattering level. As a result the user is provided the SSP

index, bottom loss province and water depth at the AOI LAT/LONG. The user has the option to display all the environmental data an each beam as shown in Figure 6. Note that the change in bathymetry and the location of Bottom loss and SSP boundaries are shown so that the user can see where the changes in the environment are occurring on a beam to beam basis.

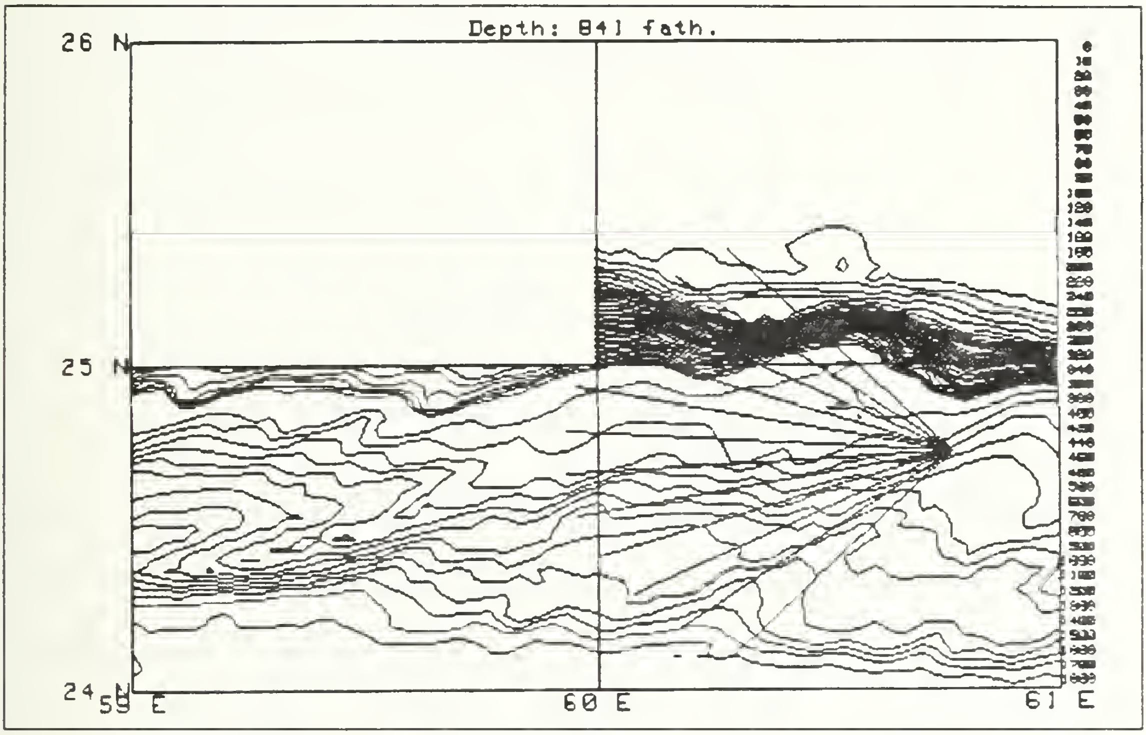


Figure 5. SAAAB Bathymetry

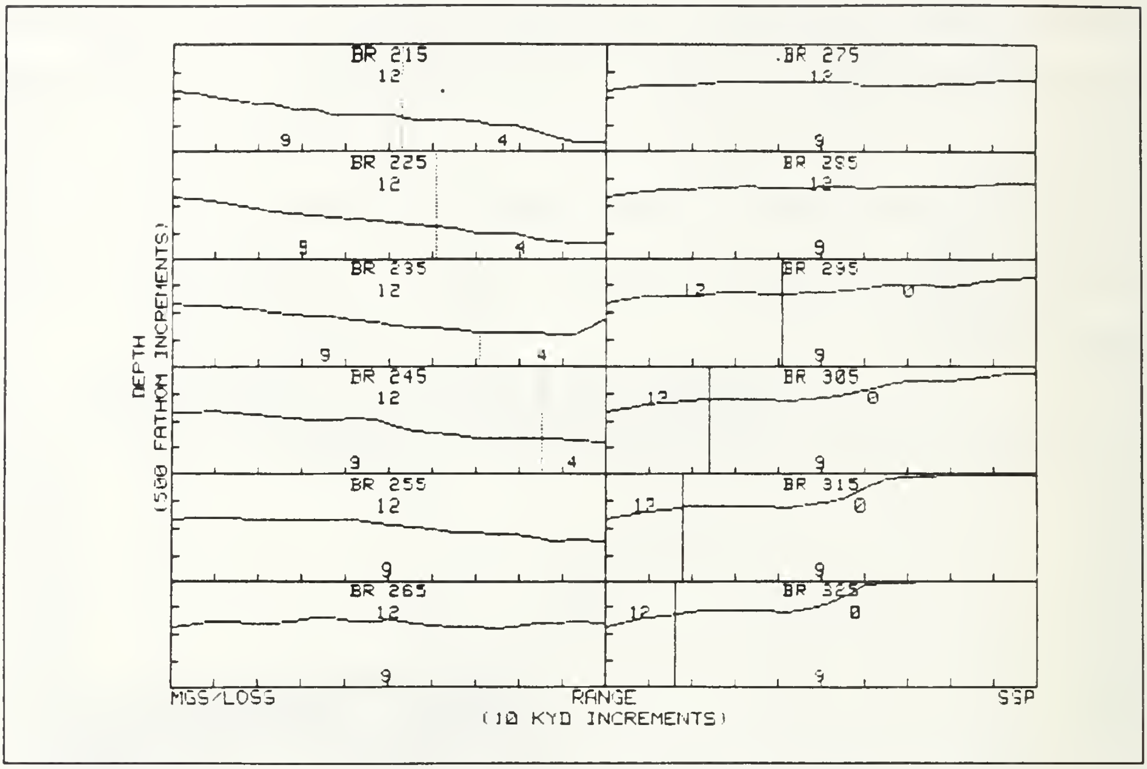


Figure 6. Beam by Beam Environmental Data

C. BATHYTHERMOGRAPH INPUT

MAPS accepts XBT profile information in one of several formats. The water temperature profile and sound speed profile are accepted in English or metric units. The SSP input menu has 5 options in which to choose from:

1) The first option is to use the historical profile which is the data base XBT for the region of interest.

2) Second, the user can choose to enter a profile and merge it with the historical profile. This option is available if the user does not have an XBT that extends to the bottom. When the data base covers the area of concern, the user can compare the input sound speed profile against the historical data backdrop (Figure 7). MAPS gives the users three choices of historical data with which to

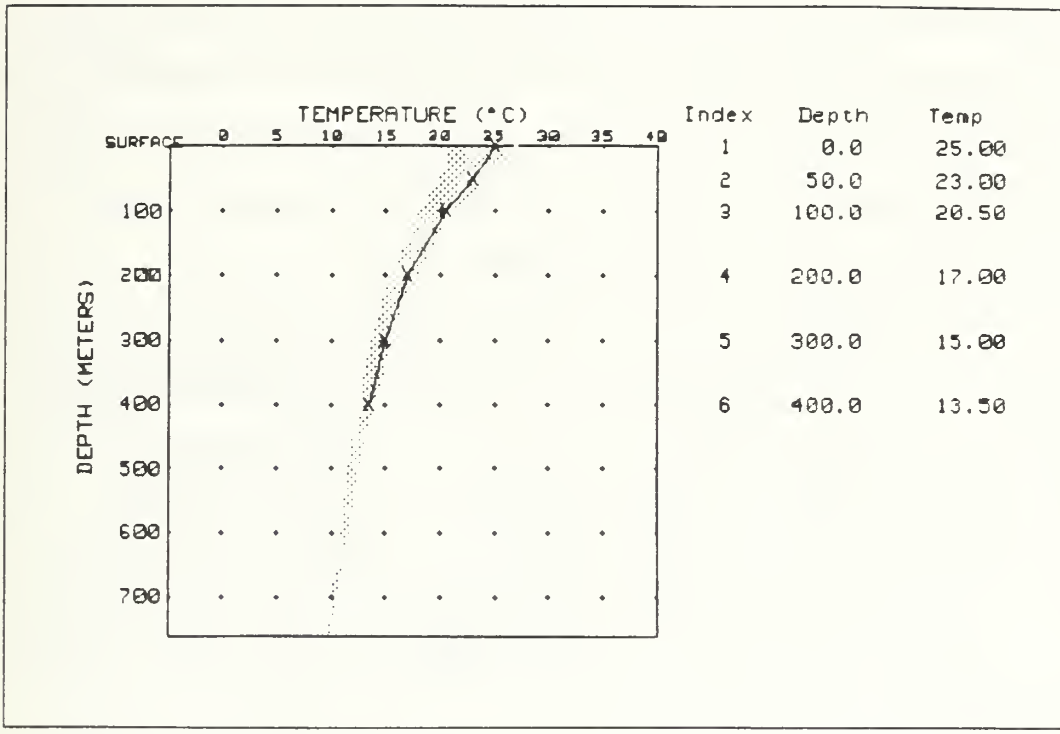


Figure 7. XBT Entry With Historical Shading

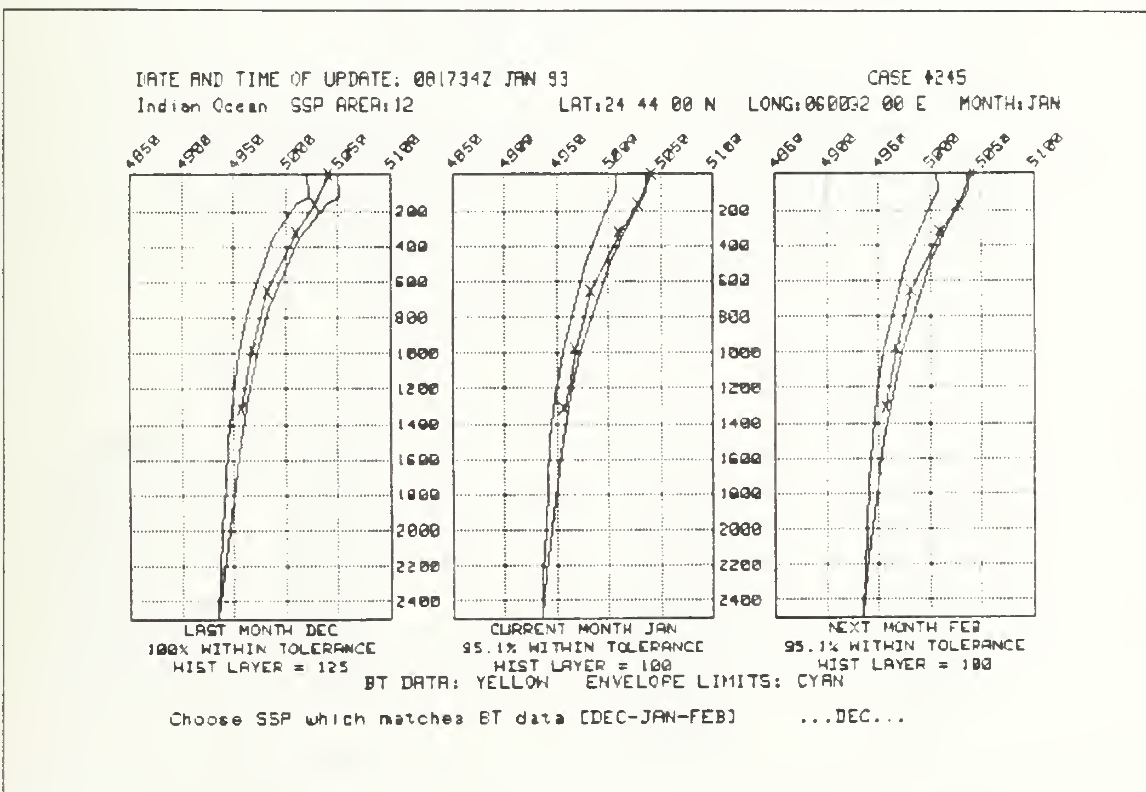


Figure 8. Three Month Historical Choice For Merge Of Data

merge the in-situ XBT. The center profile is the month that had been entered previously and the two other profiles are the months previous to and following the month inputted (Figure 8). This allows the user the option compare the XBT with the historical data base monthly data on either side of the month of interest.

3) The third option is to enter an entire profile to the bottom depth. This option gives the user the capability of using the in situ XBT data without merging to the historical SSP. This option gives the user the capability of entering up to 25 SSP's at different locations that can be used in the range dependent propagation loss calculations.

4) The fourth option is for the user to select one of the last ten XBT's on file.

5) The final option is to use the last SSP that was entered. This is a useful option and reduces data input time.

Once the selection is finished, MAPS then displays a numerical representation of depth with corresponding velocities (Figure 9). The

Environmental Update (Case #245)

Sound Speed Profile

Indian Ocean SSP Index #12

Depth	Velocity	Depth	Velocity
0	5041.23	2500	4935.00
164	5026.39	2750	4932.00
328	5011.38	3000	4930.00
656	4986.76	3250	4927.00
984	4969.29	3500	4925.00
1312	4957.37	4000	4920.00
1500	4952.41	4500	4917.00
1750	4947.81	5000	4913.00
2000	4943.21	5316	4911.42
2250	4938.60		

Figure 9. Final XBT Entry

next MAPS output is a final display of the XBT profile (Figure 10). Note that the profile is broken apart into a total profile and a shallow profile that allows the user to compare the raw input data to the final merged profile. The user then accepts or rejects the profile and either starts over or proceeds on to the propagation loss calculations.

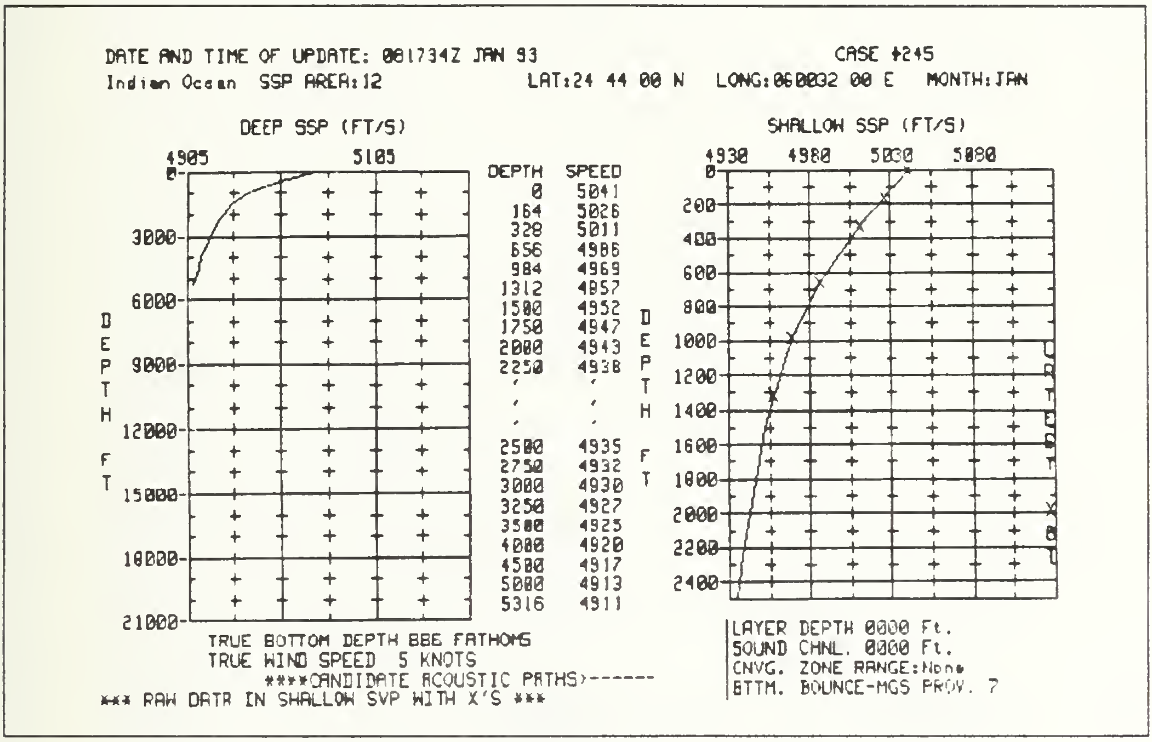


Figure 10. XBT Presentation

D. MAPS OUTPUTS

MAPS requires four additional inputs to begin the propagation loss calculations. The inputs are sonar frequency, sonar depth, target depth and stop range. The stop range determines the range resolution of the propagation loss calculation. The propagation loss calculation is done for 100 points if necessary to provide 1 kyd range resolution out to 100 kyds. The propagation·loss calculations allows displaying or not displaying the ray traces for the twelve beams that are displayed and

performs a range independent calculation for comparison. The sector center input from the first input menu determines the true bearing where beams 1 through 12 will be centered.

MAPS displays the 12 beam propagation loss upon completion of the calculations (Figure 11). The user has a three options on what to

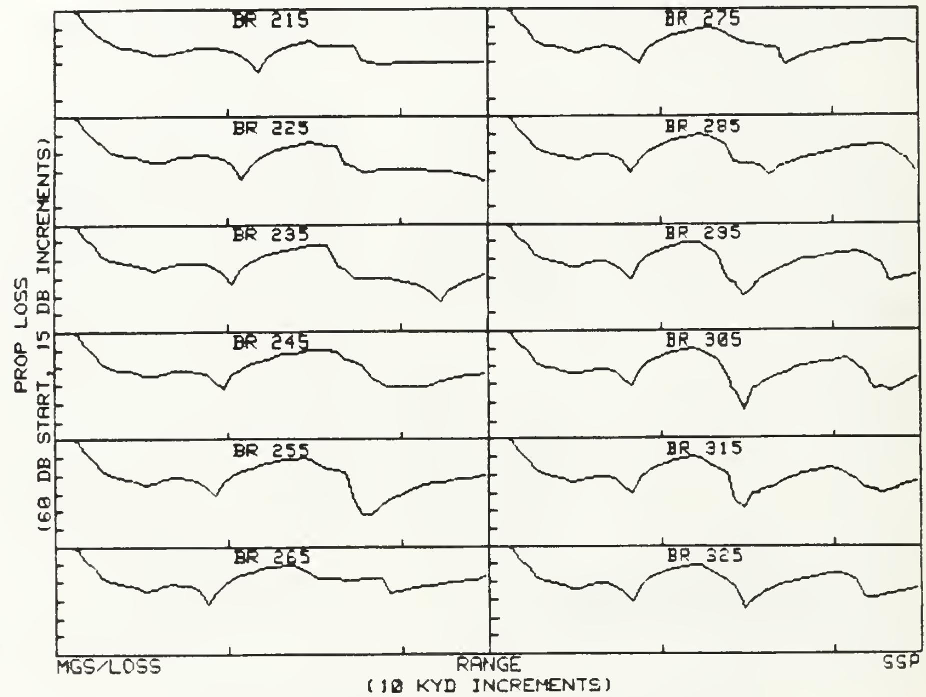


Figure 11. Twelve Beam Propagation Loss

display on the 12 beam display. First, the user can display the range independent propagation loss. Second, The user can enter a reference propagation loss which can be a manual input of propagation loss values or a MAPS range independent calculation of propagation loss. Finally, the user can select to have an environmental overlay which displays the bottom slope and XBT boundaries on each beam. This option is very helpful in determining where the bottom topography and each XBT profile

affects the propagation loss Figure 12 shows the SSP boundary changes from 13 kyds on beam 1, 12.5 kyds on beam 2, etc. MAPS has the capability to save the propagation loss file for later display and output plotting. The user can take any saved propagation loss file and compare any propagation loss from any beam in any file to any beam in any other file, or beam Vs beam propagation lost in the same file [Ref. 1]

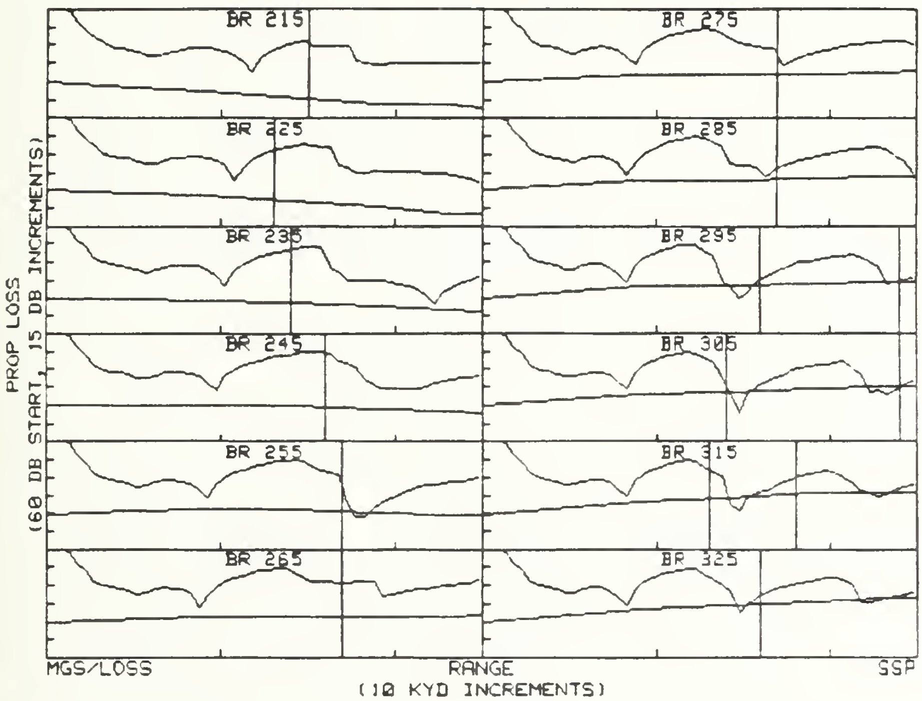


Figure 12. Environmental Overlay and XBT Boundaries

III. HIGH RESOLUTION BATHYMETRY

The SAAAB high resolution bathymetry data base has been upgraded for the Gulf of Oman areas of interest by use of special Naval Oceanographic Office bathymetry data. This upgraded bathymetry has significantly enhanced the use of the bottom topography. The bathymetry information has 10 fathom contours up to 100 fathoms, 20 fathom contours from 100 to 500 fathoms and, thereafter, 100 fathom contours. To evaluate the difference between the SAAAB data base and standard bathymetry data base, a trial case was run to illustrate the importance of bathymetry accuracy in calculations of propagation loss.

In Chapter II in Figures 4 and 5 the large difference in bottom contour definition between the SAAAB and standard data bases was identified. In this trial case a 60 ft receiver depth and 25 ft source depth was used. The first difference in the two data bases is the bottom depth calculation at own ship's position at 24-43N 060-46E. In the standard data base the water depth was 920 fathoms and the SAAAB data base produced a water depth of 841 fathoms, about a 10% difference. The bearing of interest for this trial case was 275 degrees true. Utilizing the capability of MAPS to overlay the bottom contours on the beam by beam propagation loss display and isolating the bearing of interest through a software modification that also removed the propagation loss curve, Figures 13 and 14, were generated. It is evident that the SAAAB data base provides a more detailed bathymetry

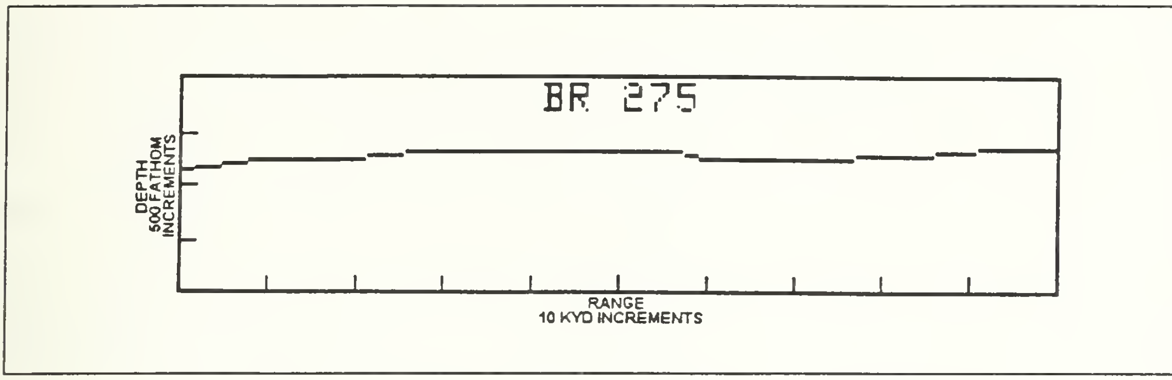


Figure 13. SAAAB Data Base Bottom Definition

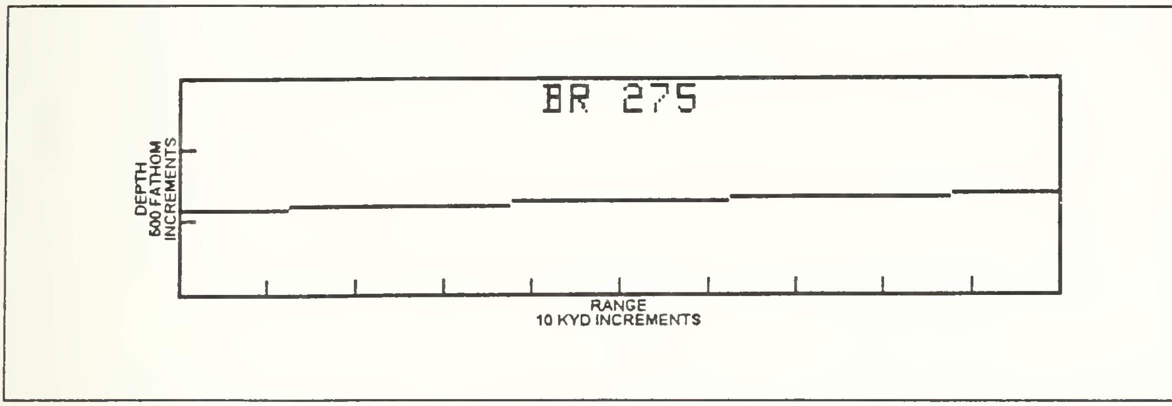


Figure 14. Standard Data Base Bottom Definition

along the bearing of interest. The propagation loss at 3.5 kHz, using MAPS' standard bathymetry data base and the SAAAB bathymetry, along the bearing 275 degrees true for each case is shown in Figure 15. This propagation loss comparison shows a significant difference in propagation loss caused only by differing bottom topography. The SAAAB data base bottom contouring propagation loss curve identifies a steeper slope, causing a bottom bounce propagation loss at shorter range than the standard bathymetry data base case. The standard bathymetry propagation loss profile indicates at 25 kyds range that there is a 16 dB higher loss prediction that is caused from different bottom.

At 18 kyds there is a 21 dB lower loss than the standard data base. These are significant changes in propagation loss that have strong tactical implications in sonar system performance assessment. This trial case shows a strong argument for a high resolution bathymetry data base to be utilized to ensure the propagation loss calculations are as accurate as possible. What is needed is to compare the accuracy of the propagation loss predictions with actual measured propagation loss. For the SHAREM 102 propagation loss measurements, the SAAAB bathymetry was used in MAPS for development of the propagation loss predictions to compare with the measured data.

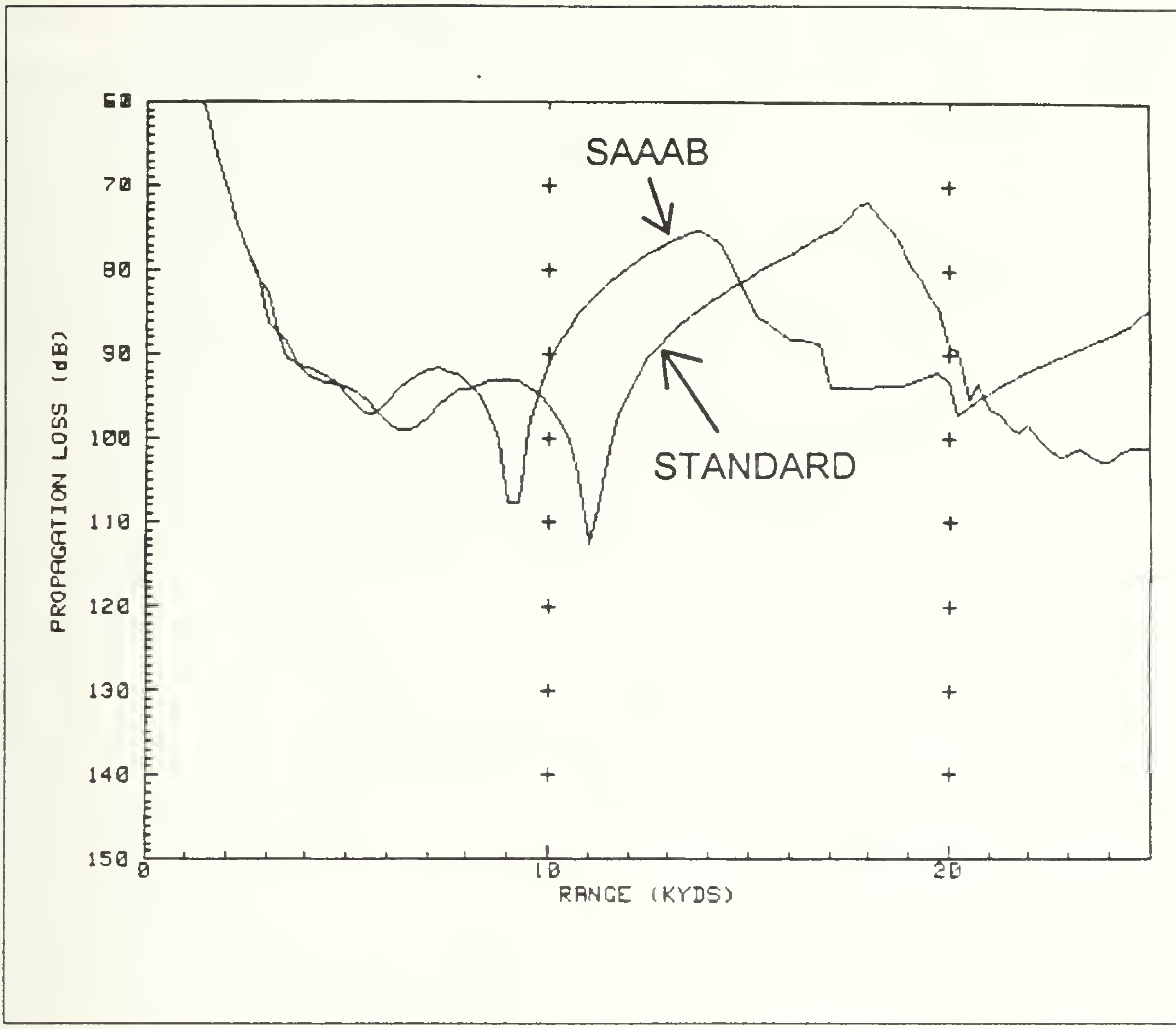


Figure 15. SAAAB Vs Standard Bathymetry Propagation Loss

IV. EVENT 08117

A. EVENT GEOMETRY AND PROCEDURES

The SHAREM 201 test plan called for environmental tests to measure propagation loss. Each event, 08117 and 10115, utilized two ships to conduct the tests with another ship collecting XBT data. The geometry for the two ship transmission loss experiments is shown in Figure 16.

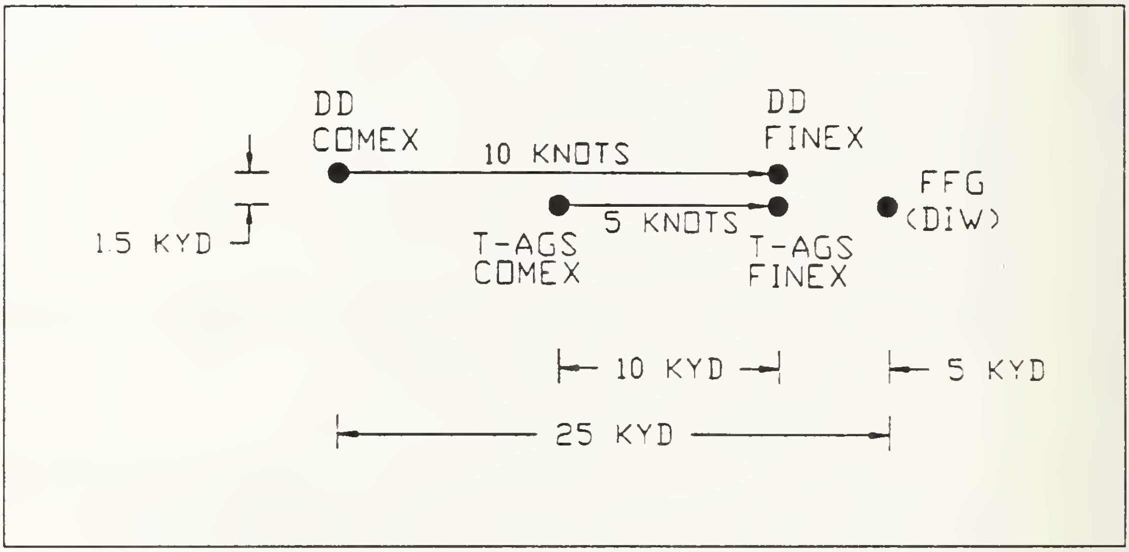


Figure 16. 3 Ship Geometry

The FFG was drifting in the water. The DD began each test at approximately 25 kyd away from the FFG and traveled 20 kyd toward the FFG at a speed of 10 knots. The T-AGS (USNS Silas Bent) began approximately 5 kyd from the FFG [Ref. 2:p5.]. The ship tracks for runs 1 and 2 for the DD and FFG are shown in Figure 17. The source frequency from the DD's AN/SQS-53 for all tests were 3.5 kHz.

Measurements of XBTs that were taken during the entire SHAREM exercise were analyzed by Naval Undersea Warfare Center Detachment New

London, CT. It was determined that there were 7 homogeneous regions of sound speed profiles as shown in Figure 18 [Ref. 3]. Figure 15 shows that Event 08117, runs 1 and 2, were conducted in an area of profile A. Of the 7 profiles determined to exist, only profiles A, C and E were profile areas that affected SHAREM propagation loss measurements. Any XBTs that ere taken during the event and were in the area of the ship

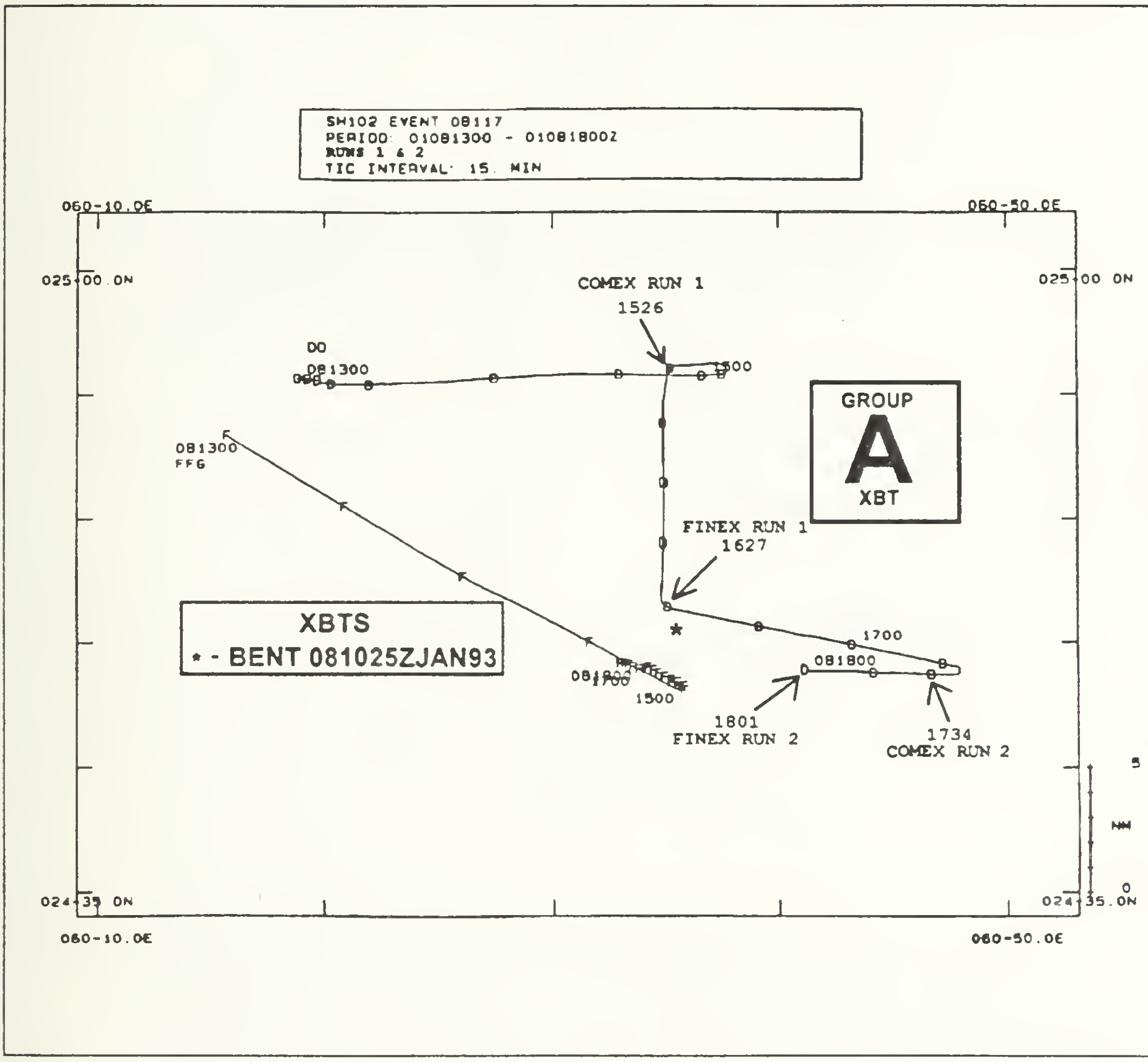


Figure 17. Event 08117 , Run 1 and 2 ship Tracks

tracks were entered into MAPS and are depicted on the Ship Tracks, Figure 15. For the own ship XBT entry, the corresponding profile XBT

that is indicated on each ship track figure was used for the entry into MAPS. All profile XBTs and in-situ XBTs that were utilized to conduct MAPS runs are contained in Appendix B.

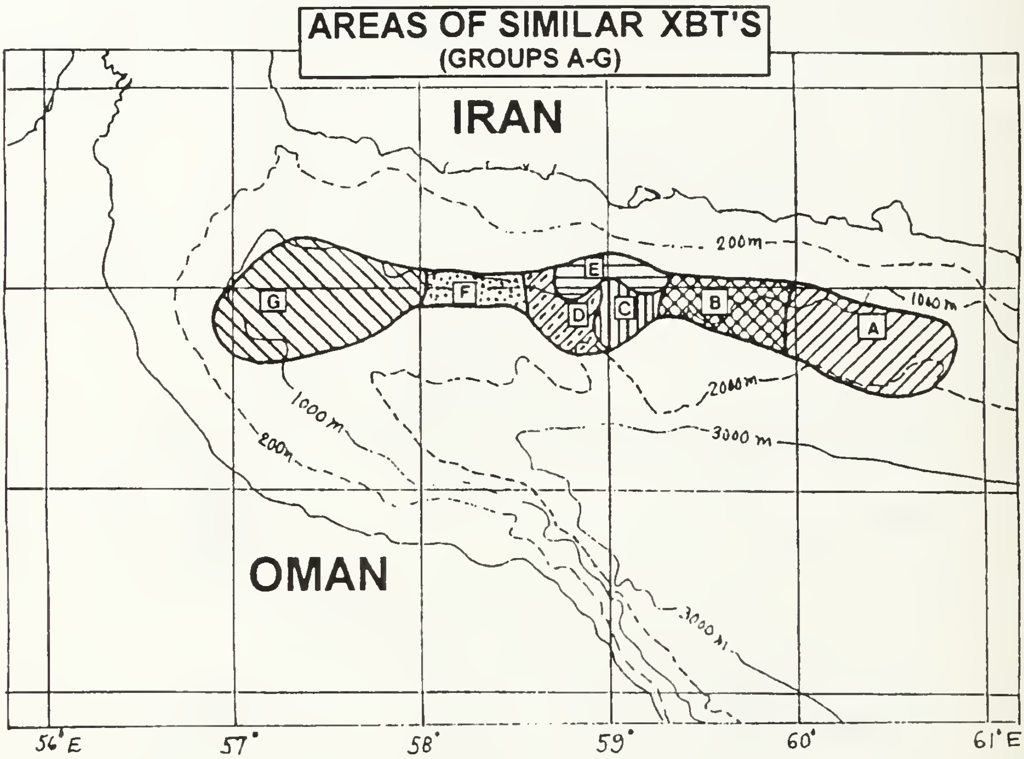


Figure 18. Chart of Homogeneous Areas in Gulf of Oman

B. EVENT 08117 RESULTS

1. Run 1

For Event 08117, Run 1, only the 60 ft hydrophone was operating due to mechanical problems with the 25 and 300 ft hydrophones. Run 1 is a down slope run with the DD at a starting depth of 500 meters and

concluding the run at 750 meters. The measured propagation loss in Figure 19 is shown as a solid line and the MAPS predicted propagation loss is a dashed line. The propagation loss is being driven by a weakly

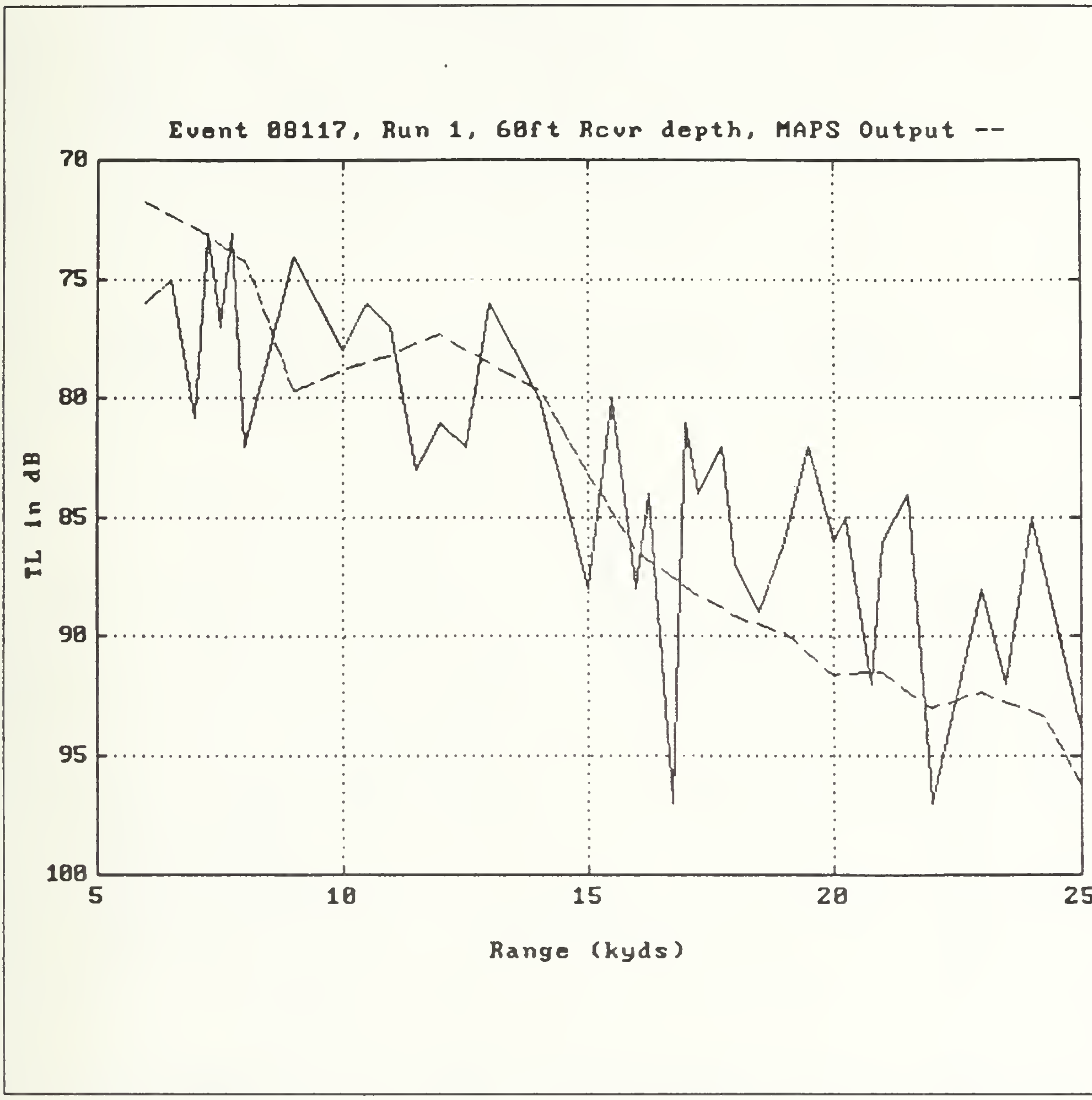


Figure 19. Comparison for Event 08117, Run 1, 60'R

formed surface duct with a layer depth of 300 ft. MAPS produces an accurate reproduction of the measured data to the 17 kyd point. At the 17 kyd point MAPS is showing approximately 5 dB more propagation loss that was experienced in the experiment.

2. Run 2

Run 2 was terminated early due to time considerations so data was only collected from the 14 to 24 kyd range from the FFG. This run was conducted across slope at a depth of 750 meters. The 300 ft hydrophone was not operating during this run. Figure 20 shows a good propagation loss prediction for the propagation loss measures at the 25 ft.

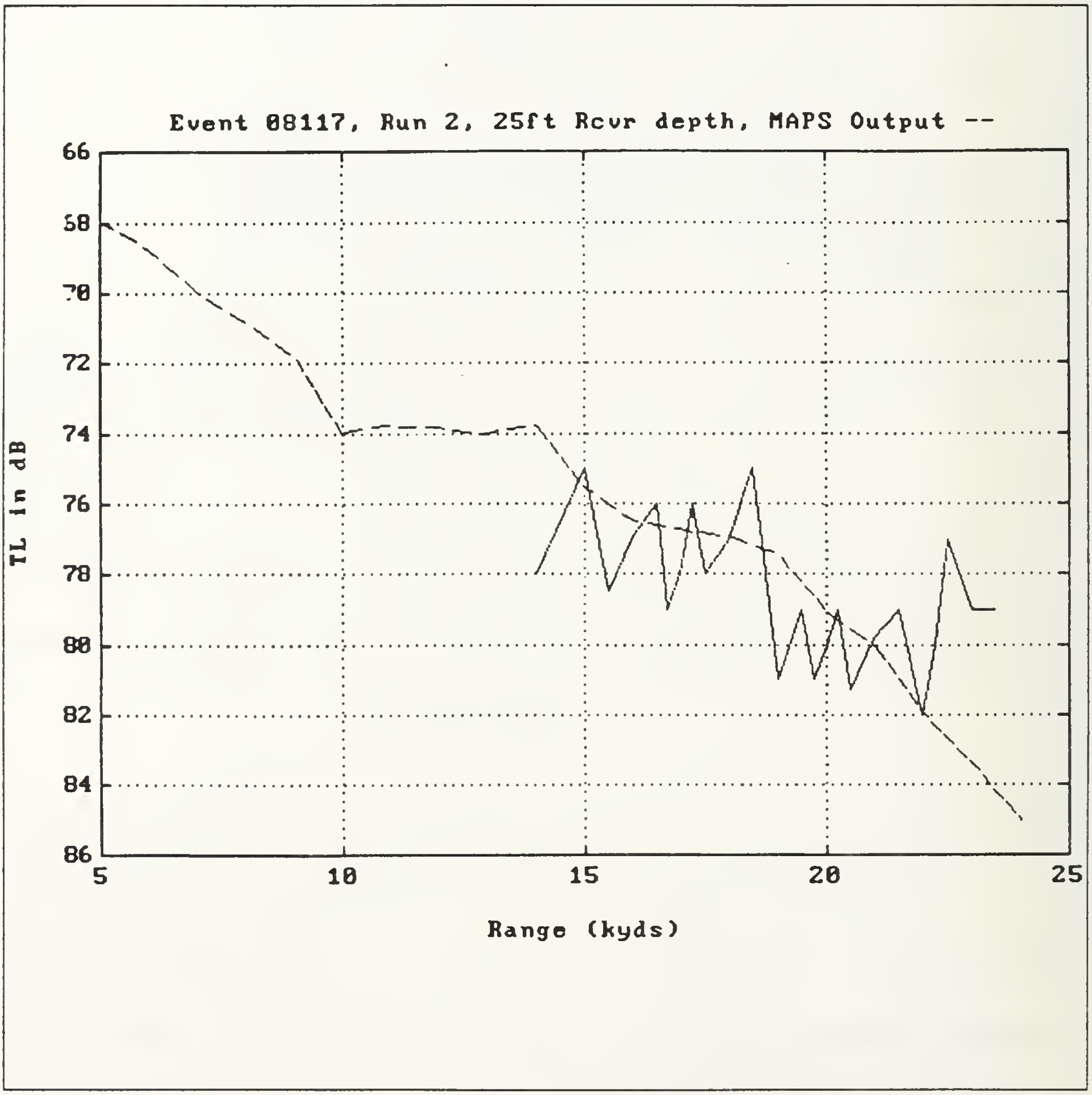


Figure 20. Comparison for Event 08117, Run 2, 25'R

hydrophone. The 60 ft receiver measured data is dominated by a bottom bounce condition. The weakly formed surface duct had little effect on the sound energy being trapped in the surface duct. The propagation loss prediction by MAPS was greater than 5 dB to low over the 14 to 24 kyd range as compared to the measured data. This lower MAPS bottom bounce propagation loss probably was caused by a too low value of bottom loss and some unaccounted for XBT data(Figure 21).

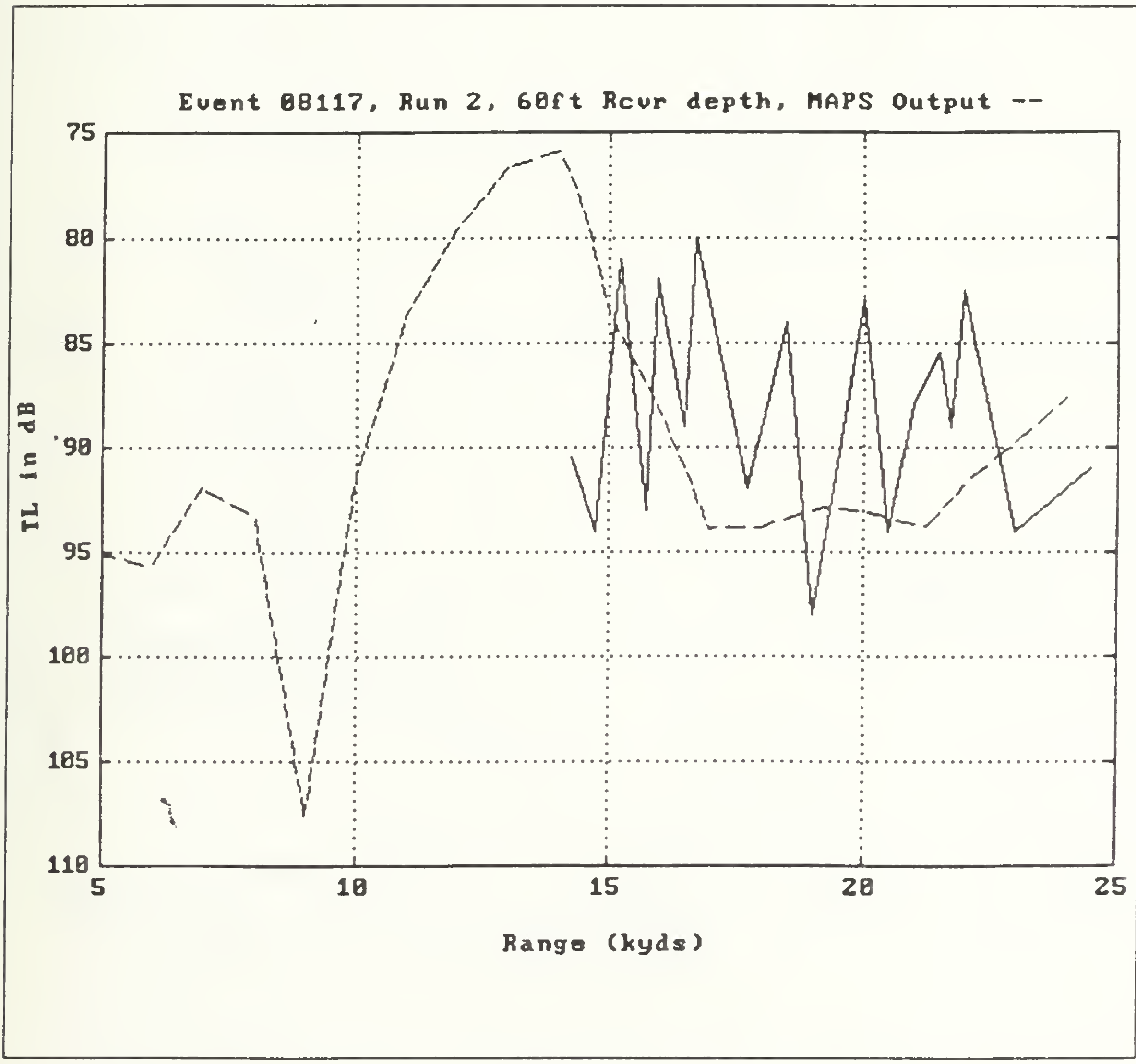


Figure 21. Comparison for Event 08117, Run 2, 60'R

V. EVENT 10115

A. RUN 1

Of the environmental down slope tests that were conducted, run 1 was conducted in the shallowest water. The starting depth was 275 meters and the finishing depth was 460 meters. Figure 22 shows the ship track for the run. Also Figure 22 identifies the profile locations and

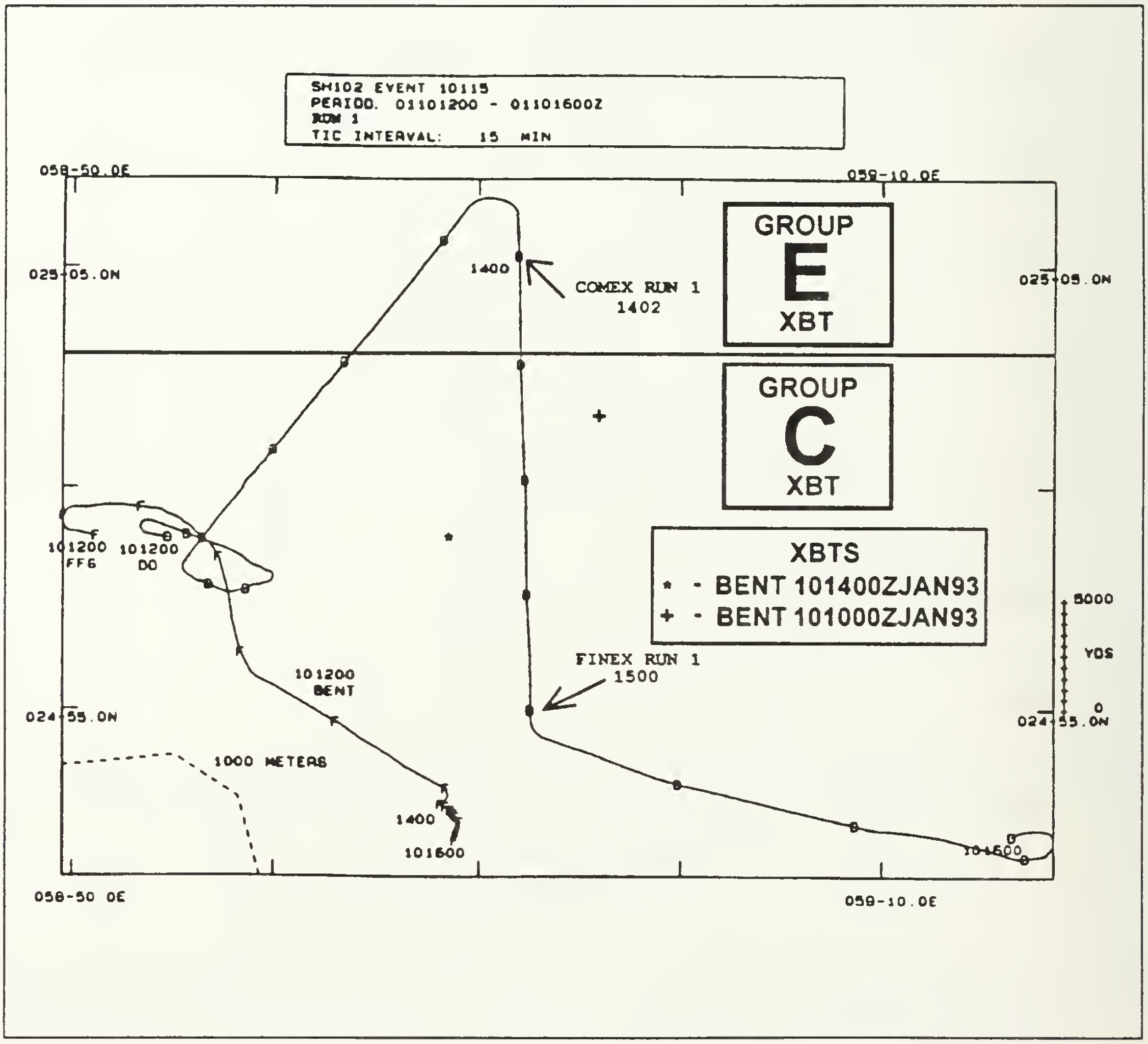


Figure 22. Event 10115, Run 1 Ship Tracks

in-situ XBTs that were recorded and used for the MAPS calculations. XBT profile E is a positive gradient with a surface layer of 300 ft and XBT profile C is a negative gradient zero layer area. As a result all three hydrophone depths exhibited unique propagation loss measurements. The 25 ft hydrophone measurement showed a strong refractive type enhancement at the 17 kyd point (Figure 23). MAPS provides a propagation loss

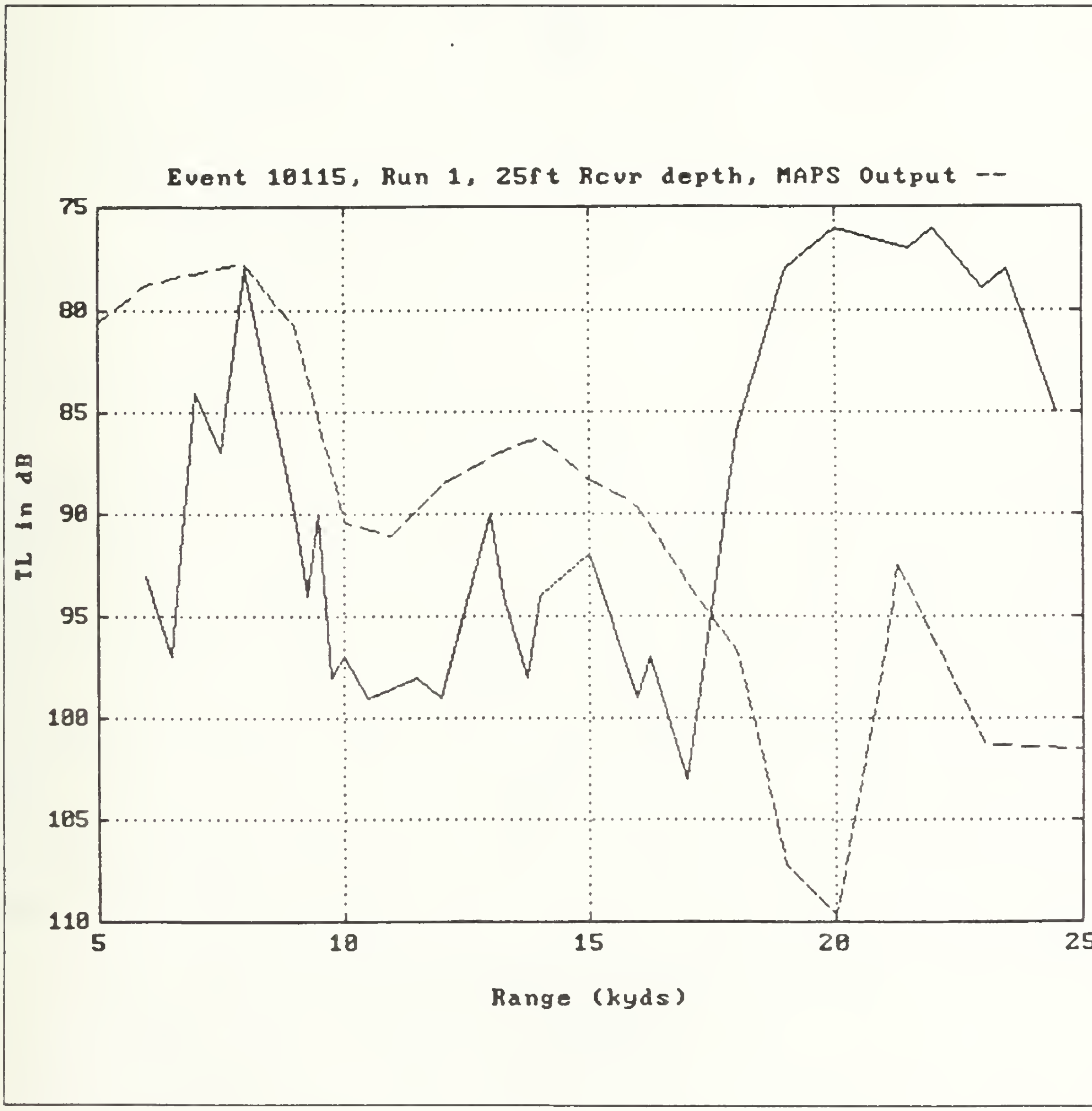


Figure 23. Comparison for Event 10115, Run 1, 25'R

prediction that is approximately 5 dB to 10 dB lower than the measured data until the 17 kyd point. It is at this point that MAPS does not satisfactorily predict the propagation loss. The MAPS' bottom bathymetry shows (Figure 24) a strong downward slope; the most severe of any run, then at 20 kyds the bottom slope begins to level off. This

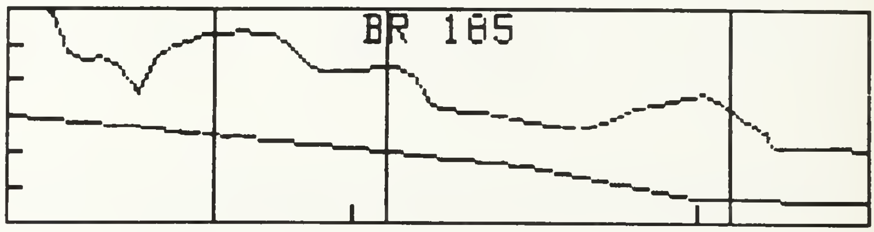


Figure 24. Bottom Contour for Run 1, 25'R

bottom contour is one of the factors that causes the discrepancy in predictions at the 17 kyd point on. The ray trace of the bearing 185 degrees true, (which can be seen on the MAPS display, but cannot be printed), shows that the change in slope of the bottom did not lend itself to measured results that can create such a focused energy level. The probable major cause of the sudden refraction type of levels after 17 kyds is a possible radical change in sound sped profile along the path. There is a reason to suspect some temporal/spatial SSP effects that were not measured during the propagation loss run.

The 60 and 300 ft hydrophone propagation loss predictions are closer to the measured data than the 25 ft case (Figures 25 and 26). Again the significant difference between the MAPS predicted propagation

loss and the measured propagation loss is probably due to lack of sufficient XBT data.

Run 1 of Event 10115 leads to the conclusion that the shallow water environment in which this run was conducted was not isotropic. Even though there were three XBT boundaries inputted in MAPS, it is concluded that the environment was changing during the run, possibly due to coastal upwelling. This case shows the importance for the need of higher resolution in-situ environmental inputs for propagation loss prediction models.

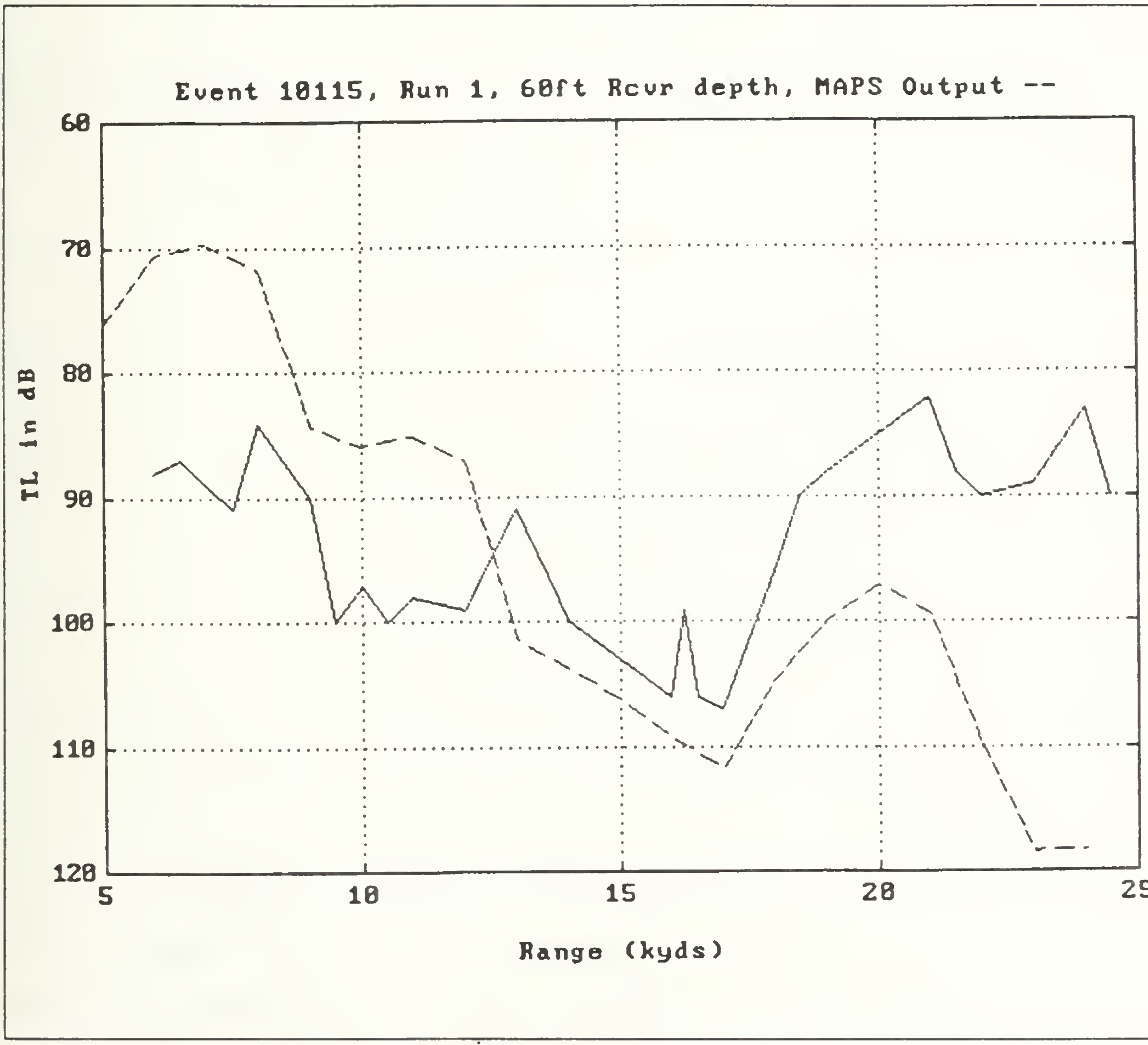


Figure 25. Comparison for Event 10115, Run 1, 60'R

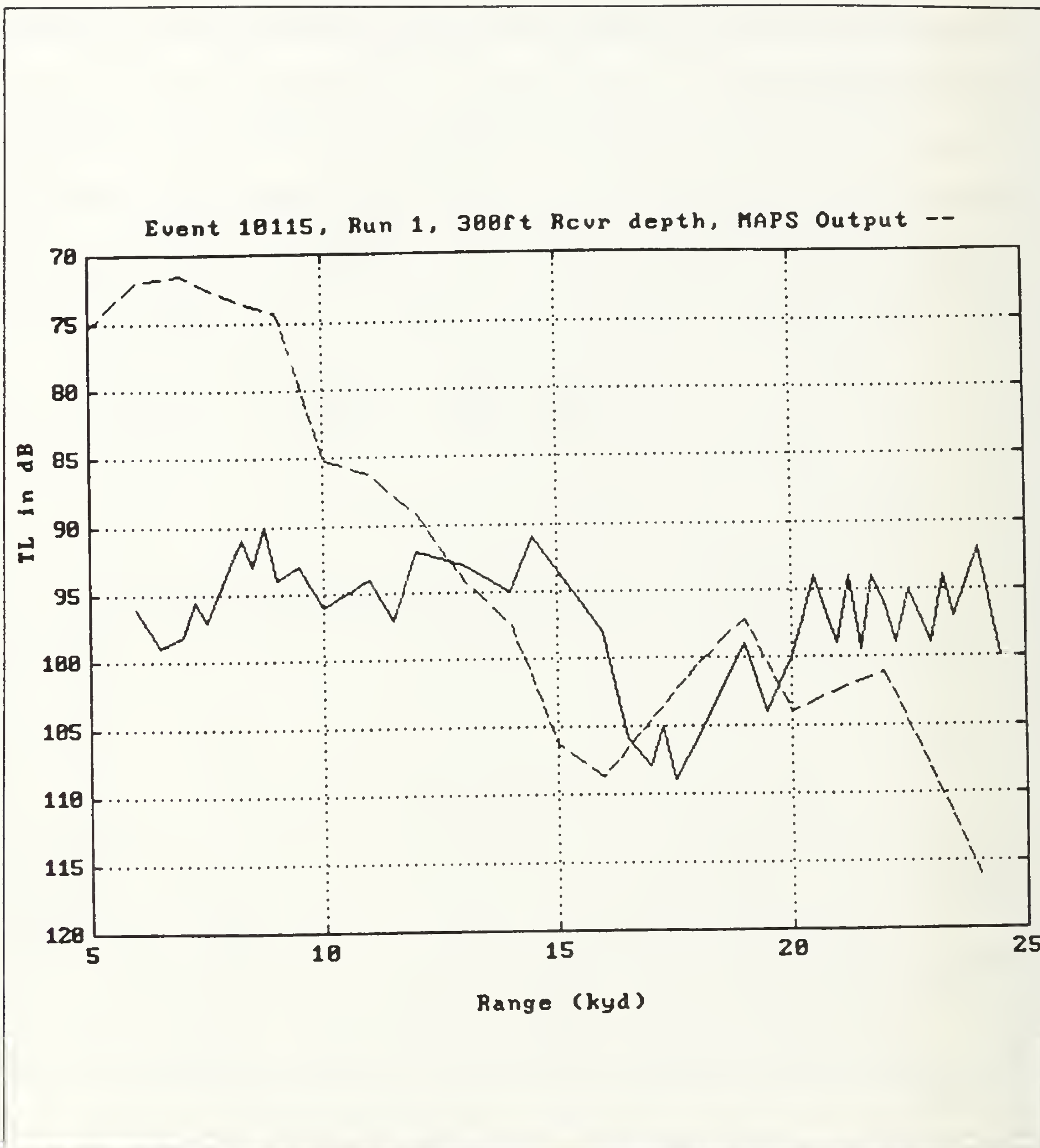


Figure 26. Comparison for Event 10115, Run 1, 300'R

B. RUN 2 AND 3

An across slope measurement was conducted for run 2 where the bottom depth was constant at 460 meters and an up slope measurement for run 3, where the beginning bottom depth was 700 meters and the ending depth was 475 meters. Figure 27 shows the ship tracks for runs 2 and 3

and the XBTs that were used to calculate the MAPS propagation loss prediction. While analyzing the MAPS Vs measured data of runs 2 and 3, it was informative to compare the range independent propagation loss

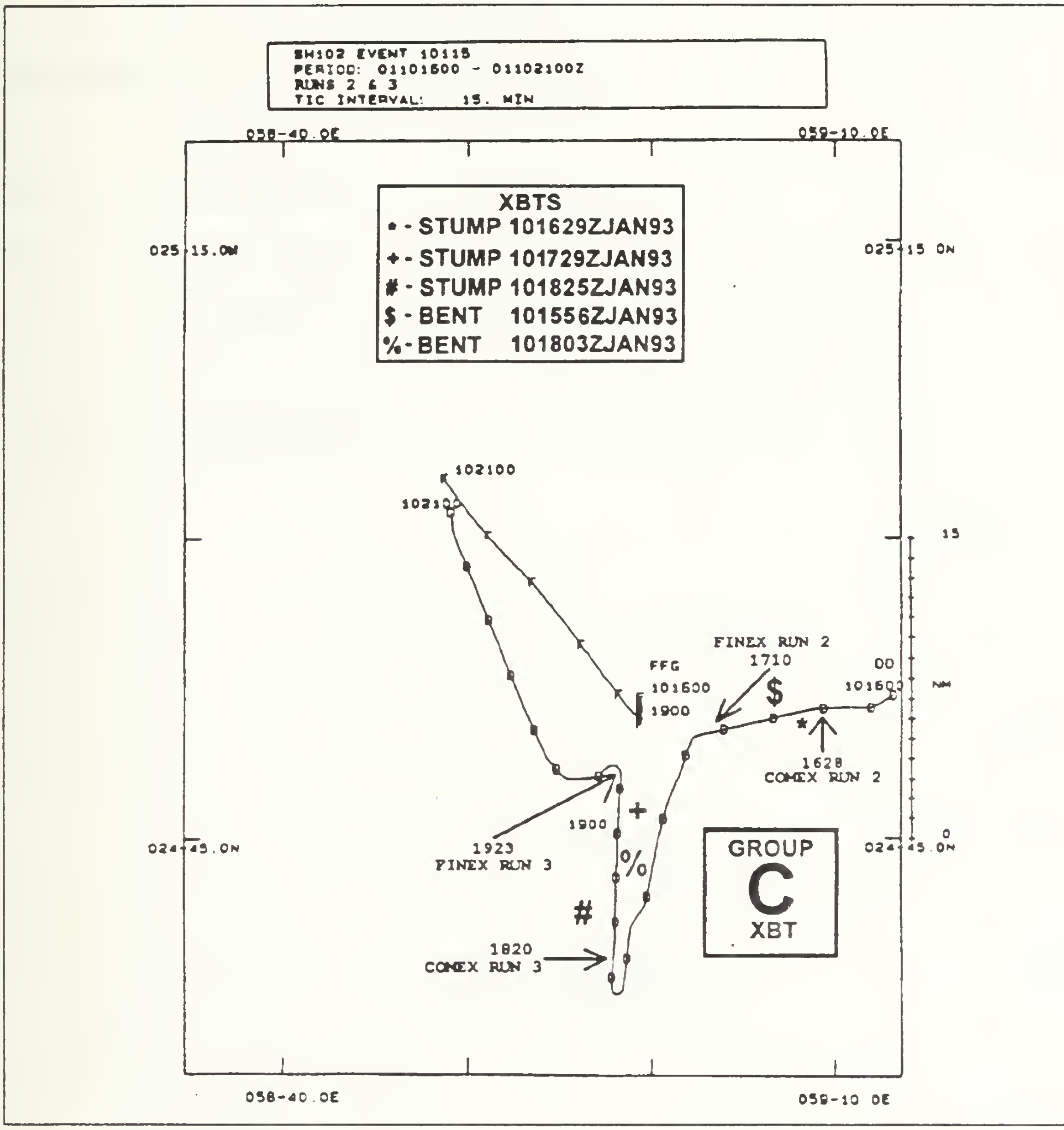


Figure 27. Event 10115, Run 2 and 3 Ship Tracks

predictions against the measured propagation loss data and the MAPS' propagation loss results. The prediction of the range independent RAYMODE was looked at in 3 of the 6 cases. These results will be used

to illustrate the importance of using a range dependent model such as MAPS in a shallow water environment Vs a range independent model. For the 3 cases that address the range dependent case Vs the range independent case, the range independent case was added to the comparison plots. The other 9 range independent plots are found in Appendix B for back ground reference.

The 25 ft hydrophone depth for run 2 is a case where there was fair agreement of MAPS predicted propagation loss and measured propagation loss but showing a significant difference in the independent prcpagation loss (Figure 28). Because the depth was constant across slope the

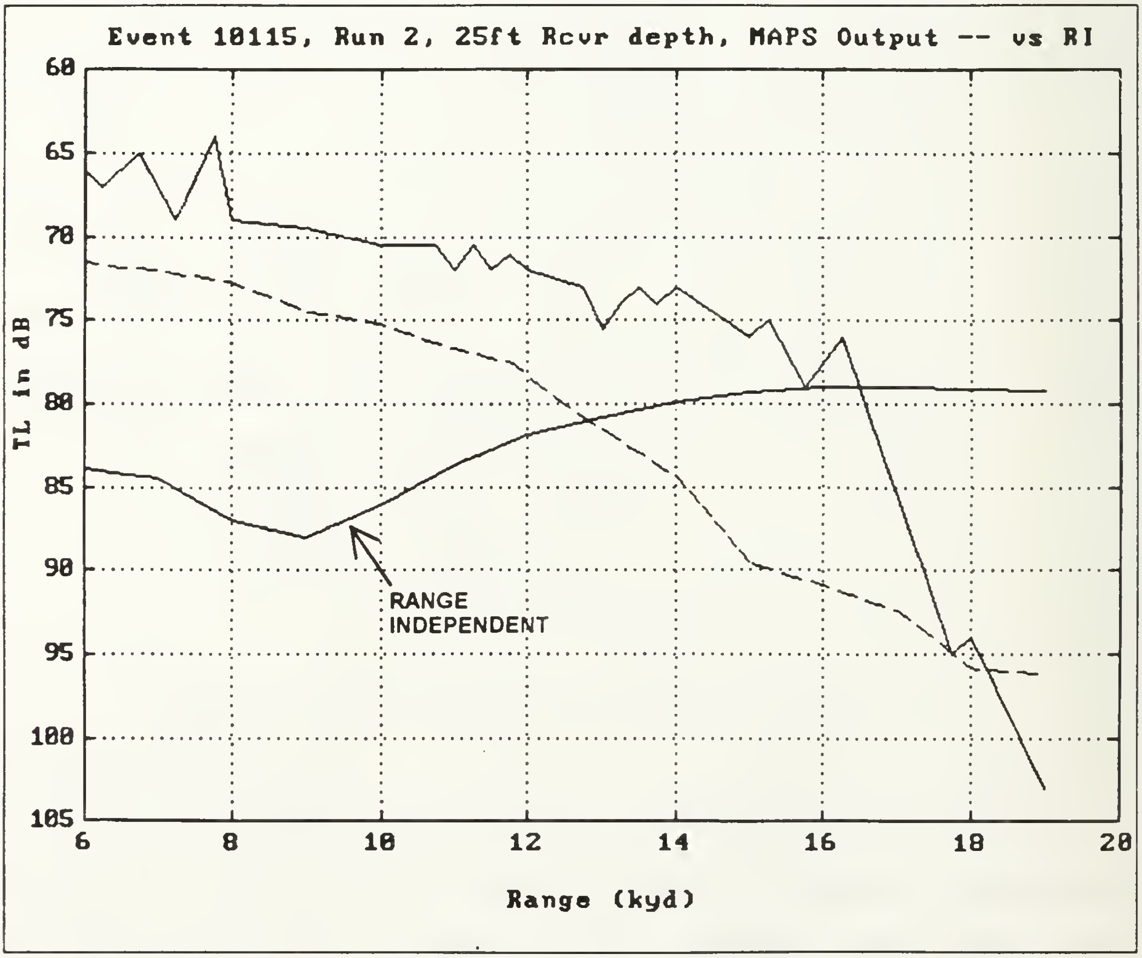


Figure 28. Comparison for Event 10115, Run 2, 25'R

difference must be because of the different XBT regions across the propagation path. Profile C was used as the XBT entry at own ship position, which showed a negative gradient. The lack of the surface duct is what causes the difference in the MAPS' prediction and the range independent prediction compared to measured data. The measured data was in a strong surface duct that accounts for the low propagation loss through the 16 kyd point. The MAPS range dependent model was not able to correctly predict the propagation loss due to the multiple XBT types across the propagation path because the baseline XBT "C" negative profile was used at own ship. Because of C's negative profile the range independent propagation shows high surface duct and bottom bounce propagation.

The 60 ft hydrophone measured data and the MAPS propagation loss prediction are in close agreement across the testing range until 17 kyds where a strong downward refraction condition occurred (Figure 29). The 300 ft hydrophone measurement was accurately predicted by MAPS (Figure 30).

For run 3 the 25 ft hydrophone case is a strong example of where the range dependency and the changing environment must be taken into consideration to accurately predict propagation loss in a shallow water environment. MAPS accurately predicts the propagation loss (Figure 31), however the range independent prediction was 20 dB to 40 dB to high in loss as compared to measured data and indicates a bottom bounce propagation situation at 15 kyd.

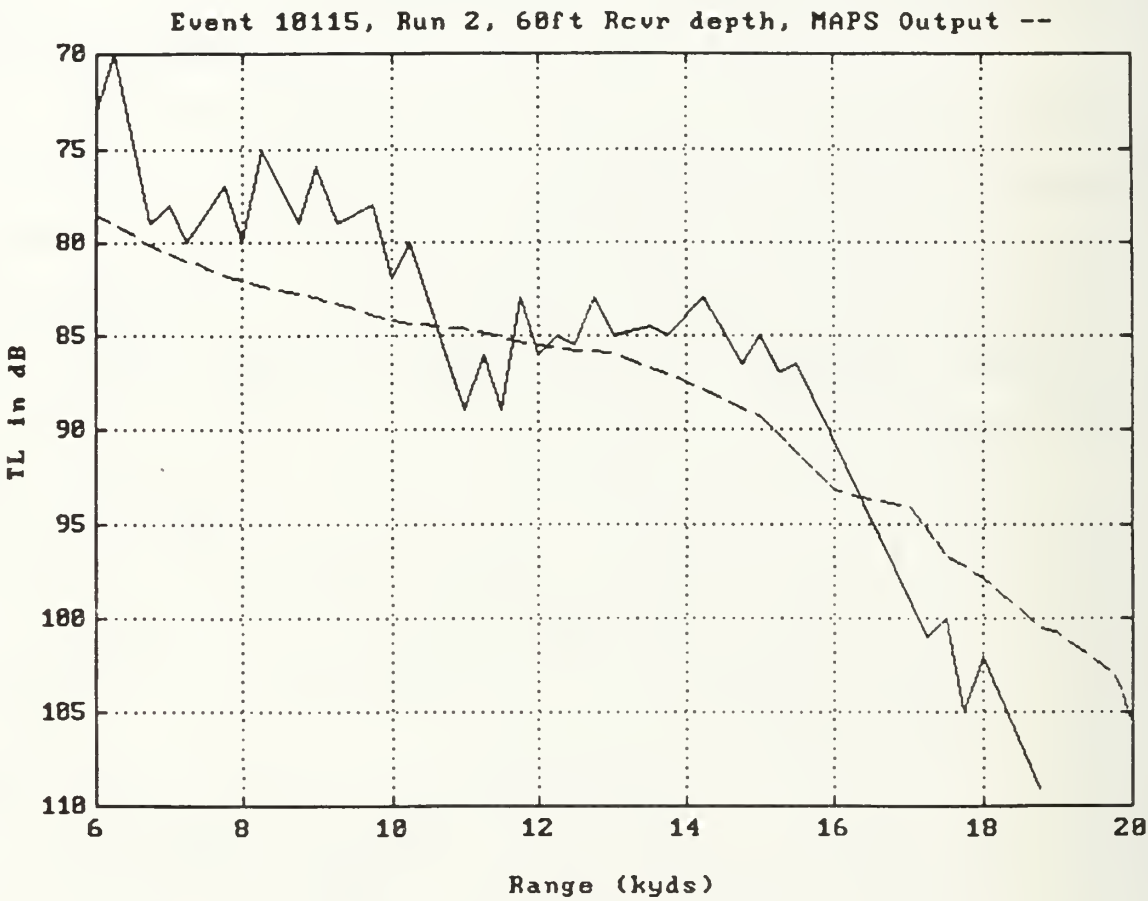


Figure 29. Comparison for Event 10115, Run2, 60'R

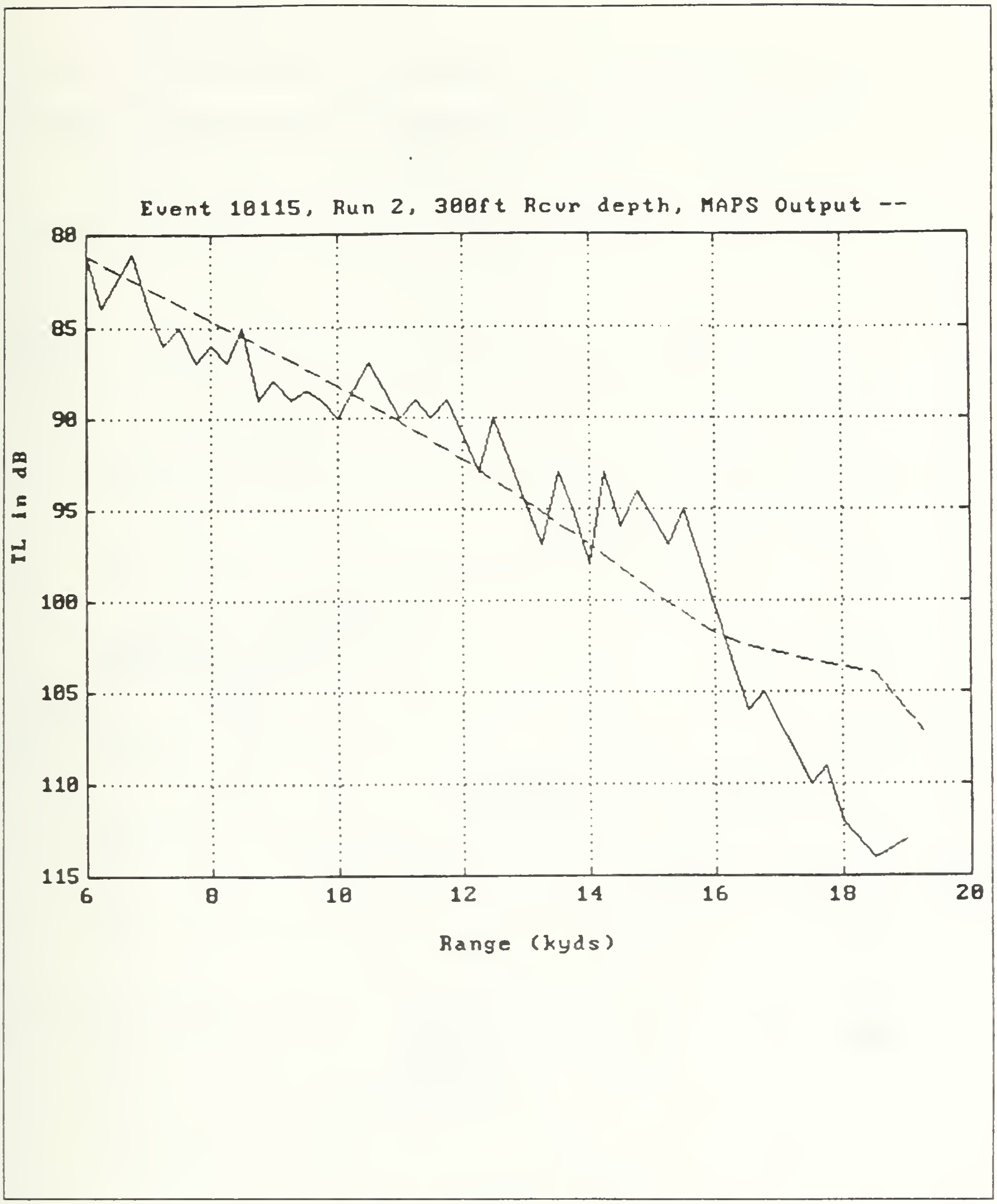


Figure 30. Comparison for Event 10115, Run 2, 300'R

For the 60 ft hydrophone case, in what seems to be a highly variable environment, MAPS provides a reasonable prediction compared to the measured data (Figure 32). The range independent prediction does

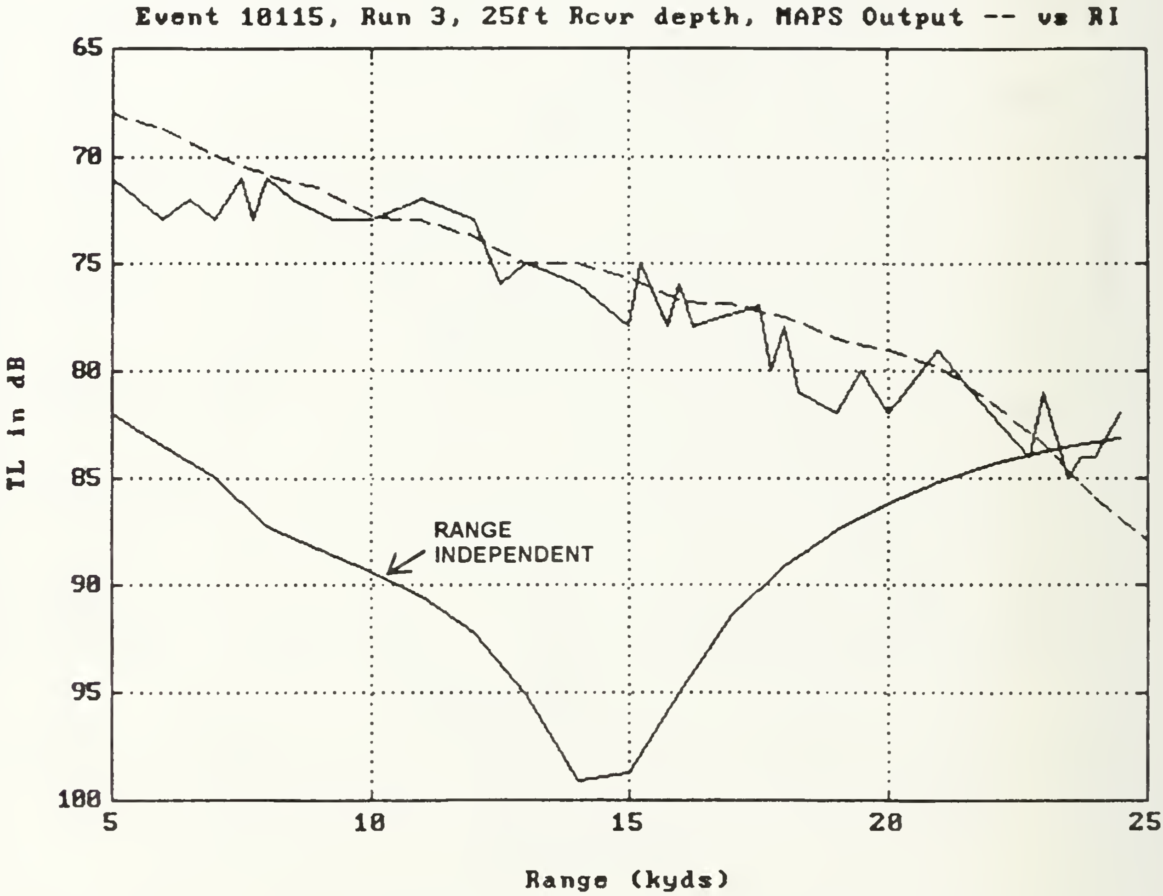


Figure 31. Comparison for Event 10115, Run 3, 25'R

not provide the correct propagation path inflection points that the MAPS range dependent model was able to generate.

In the 300 ft hydrophone case, MAPS is able to reproduce an accurate propagation loss until the 18 kyd point (Figure 33). The

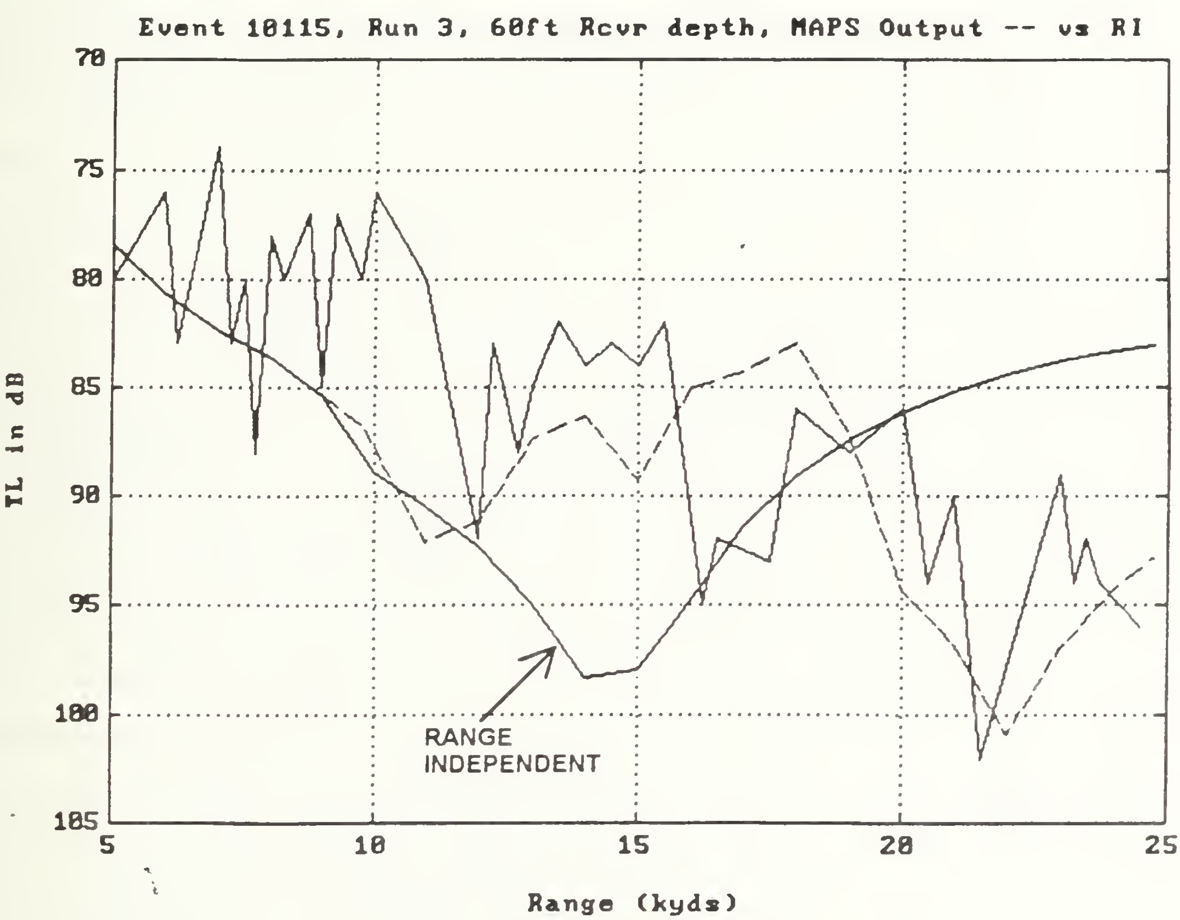


Figure 32. Comparison for Event 10115, Run 3, 60'R

measured data indicates a bottom bounce propagation which is not shown in the MAPS propagation prediction. This may be due to insufficient XBT data inputs. The range independent model shows a bottom bounce propagation loss and provides a fair reproduction of the measured data.

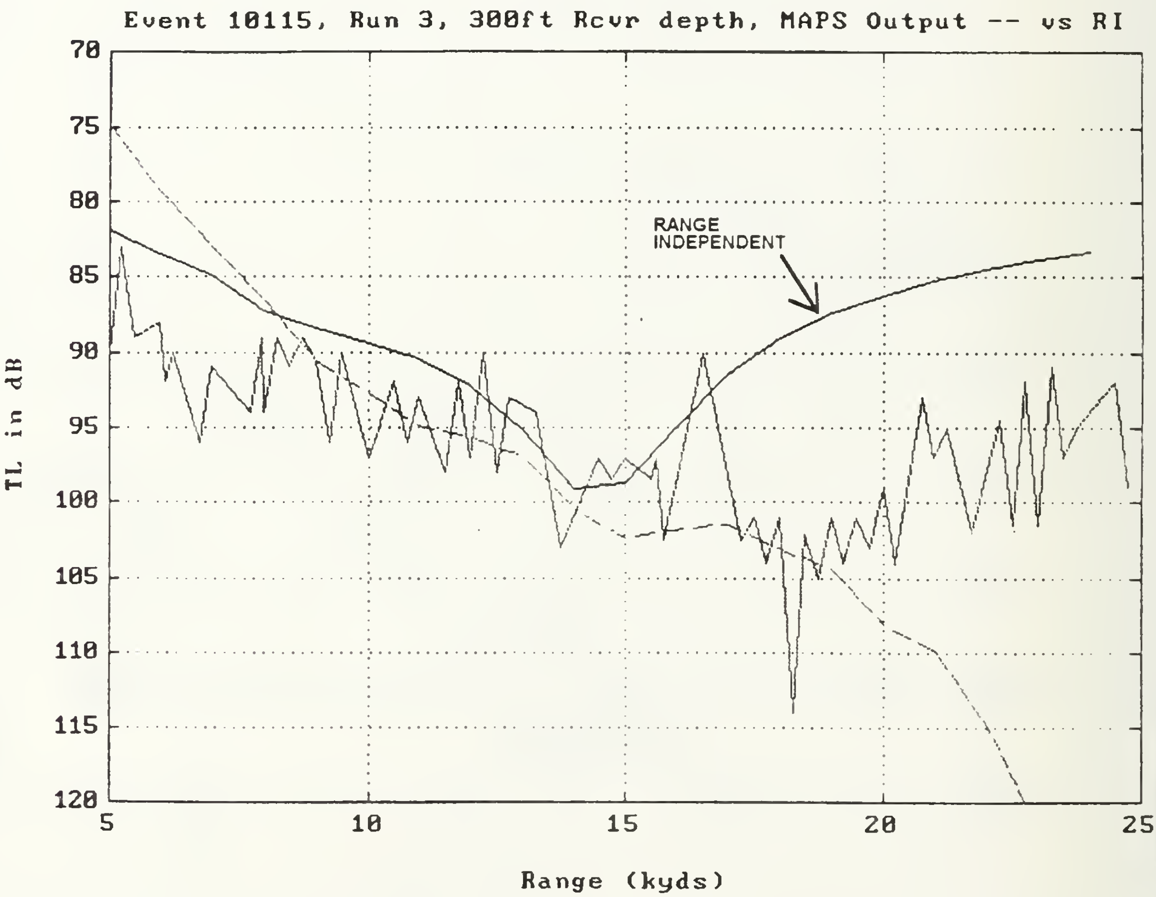


Figure 33. Comparison for Event 10115, Run 3, 300'R

VI. CONCLUSIONS AND RECOMMENDATIONS

The results that have been presented show that MAPS has the potential to produce an accurate propagation loss prediction in the littoral shallow water regions. What is meant by potential is that if high resolution environmental inputs along the acoustic path of interest are obtained an accurate propagation loss prediction can be made. Certain SHAREM measurements illustrated that the environment was changing in an hour period during the run. The SHAREM measurements strongly emphasizes the point that continuous efforts must be made to gather temporal/spatial XBT when operating in shallow water environments. During SHAREM 102 propagation measurements, a single XBT at own ship position did not possess the data necessary to predict what the propagation loss would be 25 kyd down range. Another critical environmental input for accurate littoral propagation loss prediction is the bottom loss input. As the SHAREM 102 propagation loss measurements show, the standard data of MGS 7 resulted in very high propagation loss predictions. Without the in situ SHAREM 102 calculation of bottom loss, the MAPS propagation loss predictions would not have been in the "ball park" for the bottom bounce propagation loss predictions. Also a range independent model cannot account for the environmental changes along the acoustic path of interest to accurately predict the propagation loss as it can provide highly inaccurate results that may cause the tactical commander to use incorrect tactics in a littoral shallow water environment.

MAPS has shown that in a littoral shallow water region that the resolution of the bathymetry can be an important factor in obtaining an accurate propagation loss prediction. MAPS' SAAAB high resolution data base has enhanced the prediction capability.

MAPS has illustrated that with accurate environmental inputs that accurate propagation loss can be provided to the tactical user. The amount of data that is needed to provide useful propagation loss predictions would present a problem for the Anti-Submarine Warfare Commander. No longer can a CV Battle Group designate a single XBT guard ship for obtaining all environmental data for ASW prosecution. In littoral shallow water regions it becomes the responsibility of all assets in the group to obtain as much environmental data as possible given the tactical situation. Helicopters must play a major role in this gathering process since they are the only asset that can proceed down the threat bearing and obtain XBT data and relay the data back in real time.

Another problem exists that must be addressed with the inputs of environmental data to MAPS. The process must change from a stand alone acoustic prediction system where each ship obtains its own XBT data and manually inputs the XBT in MAPS, to a system that can link from helicopter to ship to ship so that the XBT data can be used and transferred by the group in a real time manner. In addition, better user friendly software must be implemented that provide semi-automatic assistance to the MAPS operator that allows the decision as to where the boundaries should extend for a specific or group of XBTs. This XBT use assessment must be accomplished on a temporal/spatial basis in the littoral environment as the SHAREM 102 propagation loss measurements

have shown. This capability must occur before MAPS will become a useful tactical tool to the Anti-Submarine Warfare Commander.

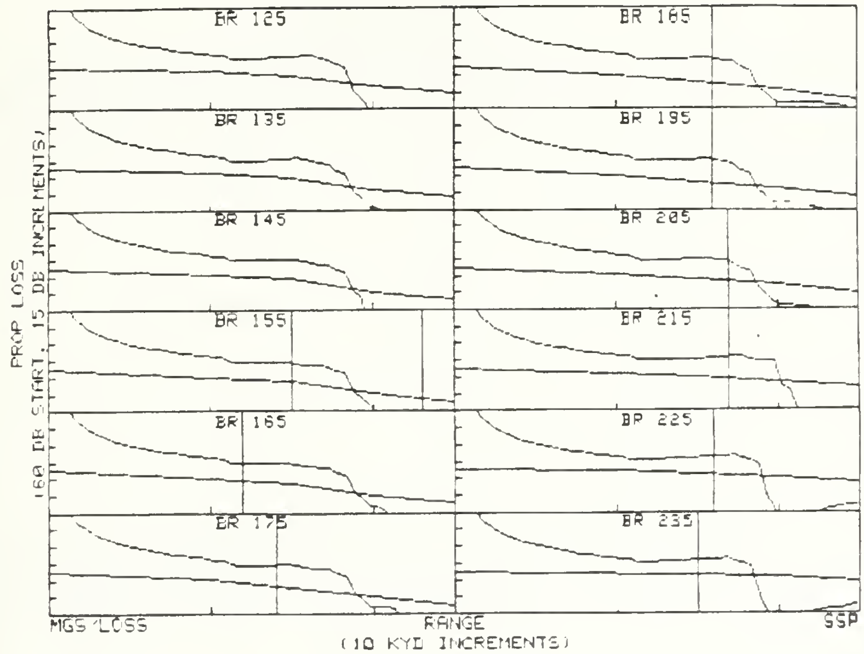
LIST OF REFERENCES

1. Huggins, Jeff A., Investigation of a Tactical Active Multi-Environment Acoustic Prediction System, M.S. Thesis, Naval Postgraduate School, Monterey, CA, 1992.

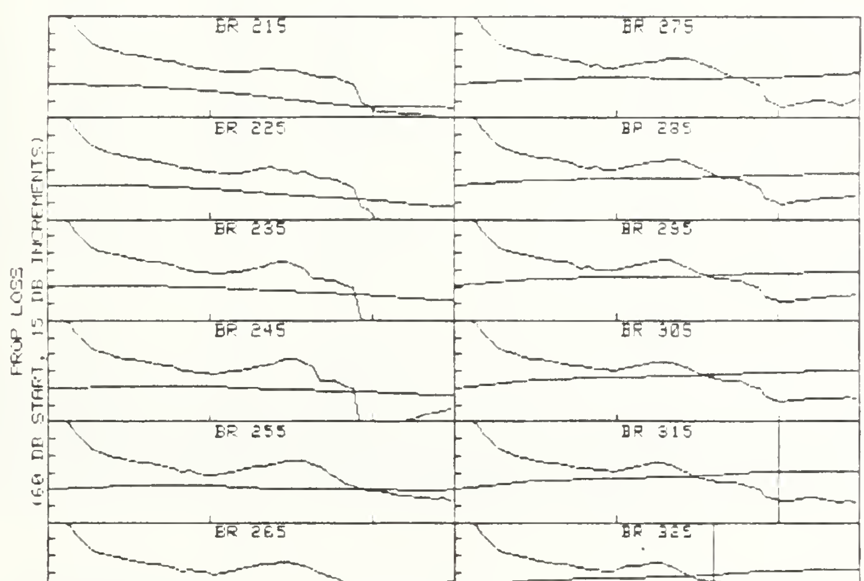
2. Naval Undersea Warfare Center Division Newport Report 68, Propagation Loss Measurements In The Gulf Of Oman, by P. Abbot, D. Morton and I. Dyer, April 1993.

3. Naval Undersea Warfare Center Detachment New London Report 931077, Gulf Of Oman Environmental Study, by E. M. Podeszwa, 30 June 1993.

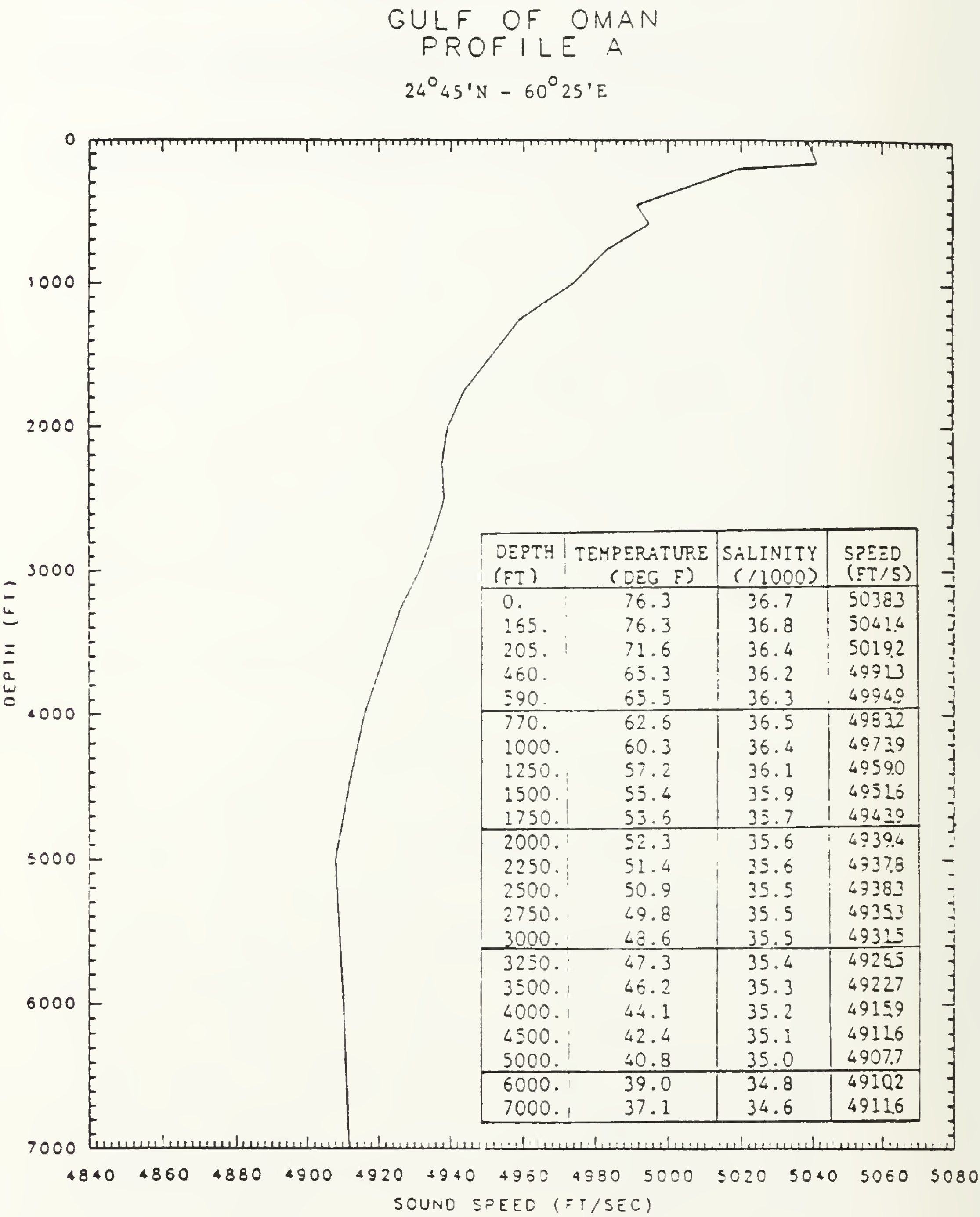
APPENDIX A



Event 08117, Run 1, 60'R with MGS province 7 used.



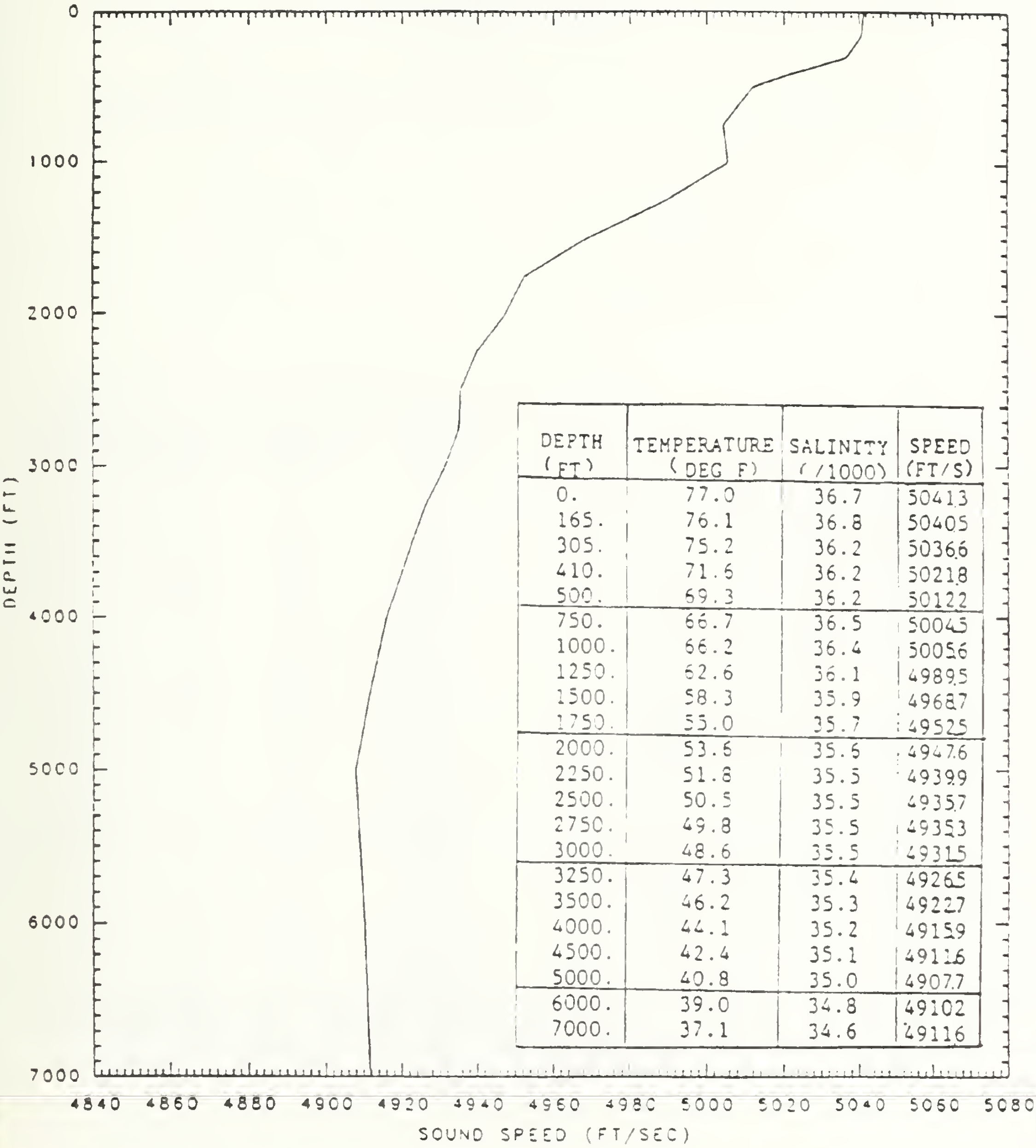
Event 08117, Run 2, 60'R with MGS province 7 used.



DEPTH (FT)	TEMPERATURE (DEG F)	SALINITY (/1000)	SPEED (FT/S)
0.	76.3	36.7	5038.3
165.	76.3	36.8	5041.4
205.	71.6	36.4	5019.2
460.	65.3	36.2	4991.3
590.	65.5	36.3	4994.9
770.	62.6	36.5	4983.2
1000.	60.3	36.4	4972.9
1250.	57.2	36.1	4959.0
1500.	55.4	35.9	4951.6
1750.	53.6	35.7	4943.9
2000.	52.3	35.6	4939.4
2250.	51.4	35.6	4937.8
2500.	50.9	35.5	4938.3
2750.	49.8	35.5	4935.3
3000.	48.6	35.5	4931.5
3250.	47.3	35.4	4926.5
3500.	46.2	35.3	4922.7
4000.	44.1	35.2	4915.9
4500.	42.4	35.1	4911.6
5000.	40.8	35.0	4907.7
6000.	39.0	34.8	4910.2
7000.	37.1	34.6	4911.6

GULF OF OMAN
PROFILE C

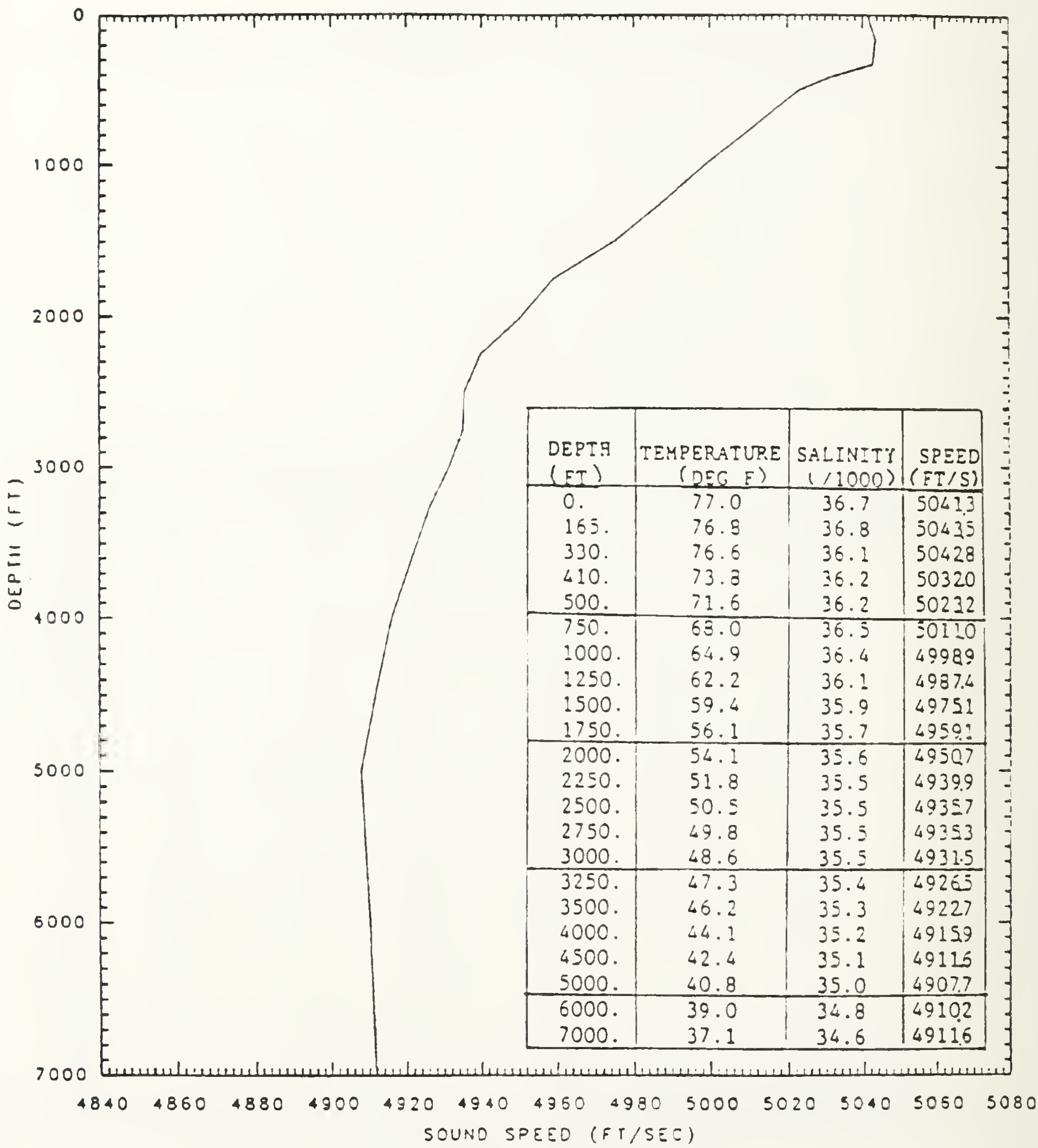
$24^{\circ}55'N - 59^{\circ}05'E$



DEPTH (FT)	TEMPERATURE (DEG F)	SALINITY (/1000)	SPEED (FT/S)
0.	77.0	36.7	5041.3
165.	76.1	36.8	5040.5
305.	75.2	36.2	5036.6
410.	71.6	36.2	5021.8
500.	69.3	36.2	5012.2
750.	66.7	36.5	5004.5
1000.	66.2	36.4	5005.6
1250.	62.6	36.1	4989.5
1500.	58.3	35.9	4968.7
1750.	55.0	35.7	4952.5
2000.	53.6	35.6	4947.6
2250.	51.8	35.5	4939.9
2500.	50.5	35.5	4935.7
2750.	49.8	35.5	4935.3
3000.	48.6	35.5	4931.5
3250.	47.3	35.4	4926.5
3500.	46.2	35.3	4922.7
4000.	44.1	35.2	4915.9
4500.	42.4	35.1	4911.6
5000.	40.8	35.0	4907.7
6000.	39.0	34.8	49102
7000.	37.1	34.6	49116

GULF OF OMAN
PROFILE E

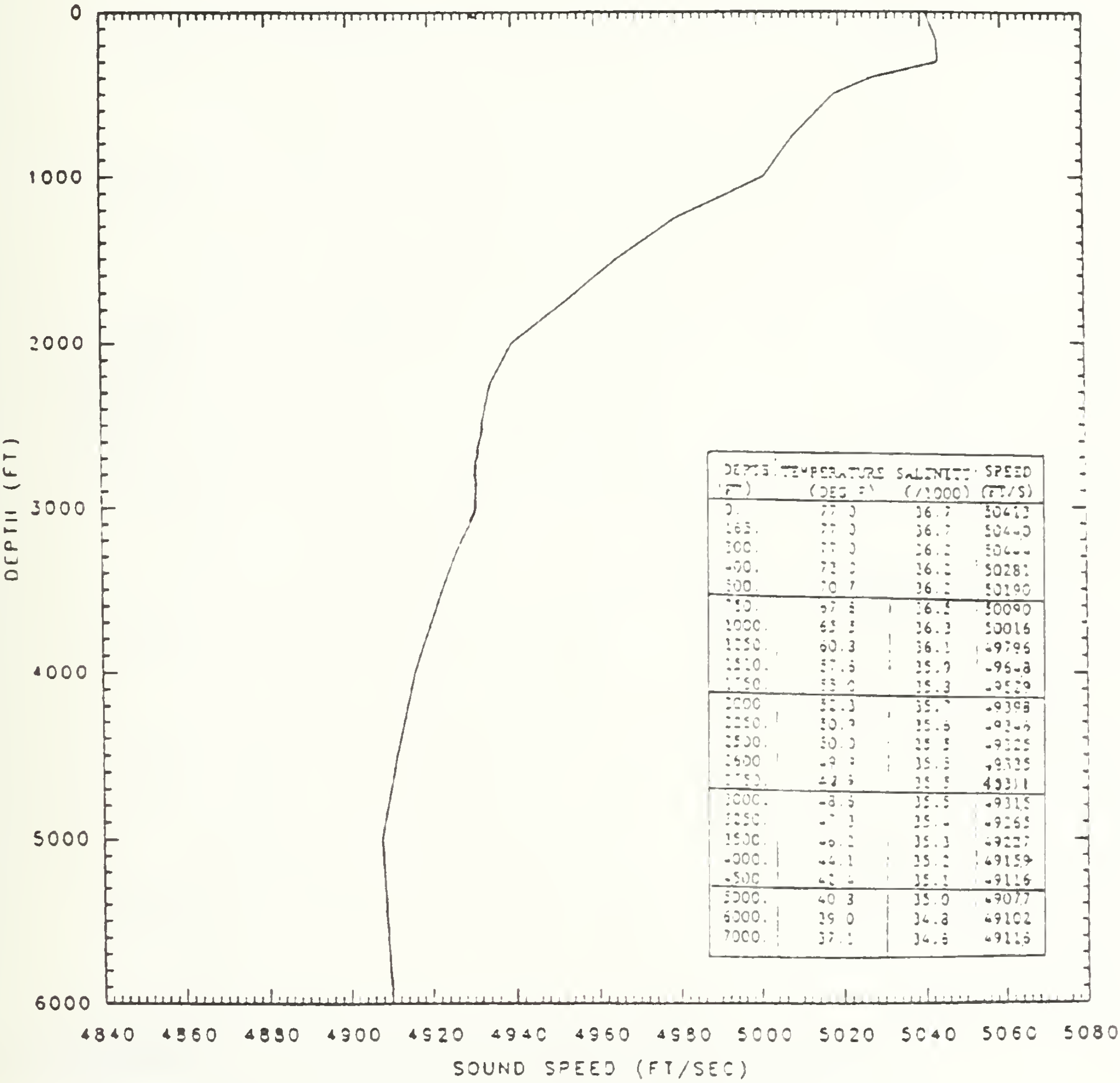
25°05'N - 59°05'E

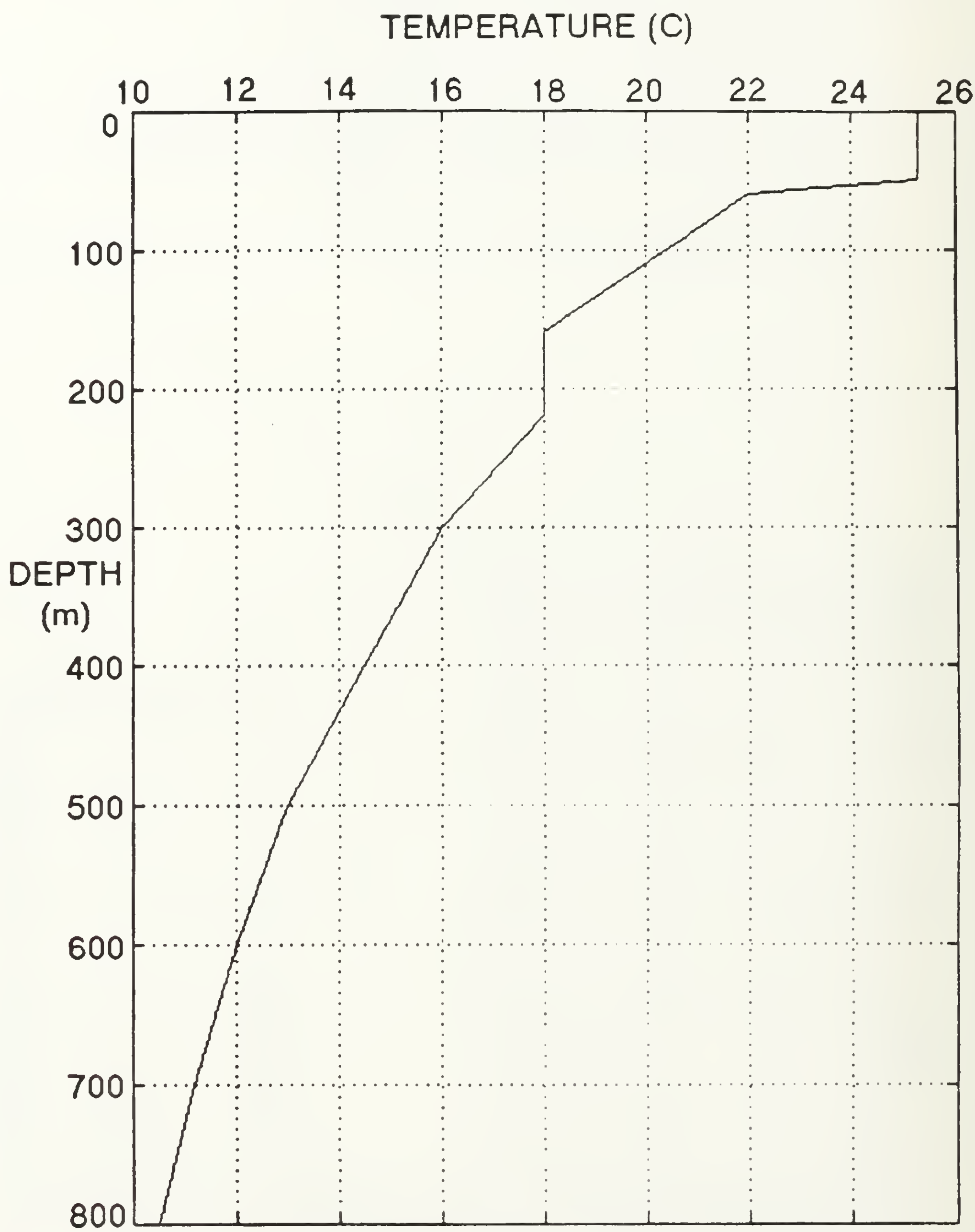


DEPTH (FT)	TEMPERATURE (DEG F)	SALINITY (/1000)	SPEED (FT/S)
0.	77.0	36.7	5041.3
165.	76.8	36.8	5043.5
330.	76.6	36.1	5042.8
410.	73.8	36.2	5032.0
500.	71.6	36.2	5023.2
750.	68.0	36.5	5011.0
1000.	64.9	36.4	4998.9
1250.	62.2	36.1	4987.4
1500.	59.4	35.9	4975.1
1750.	56.1	35.7	4959.1
2000.	54.1	35.6	4950.7
2250.	51.8	35.5	4939.9
2500.	50.5	35.5	4935.7
2750.	49.8	35.5	4935.3
3000.	48.6	35.5	4931.5
3250.	47.3	35.4	4926.5
3500.	46.2	35.3	4922.7
4000.	44.1	35.2	4915.9
4500.	42.4	35.1	4911.5
5000.	40.8	35.0	4907.7
6000.	39.0	34.8	4910.2
7000.	37.1	34.6	4911.6

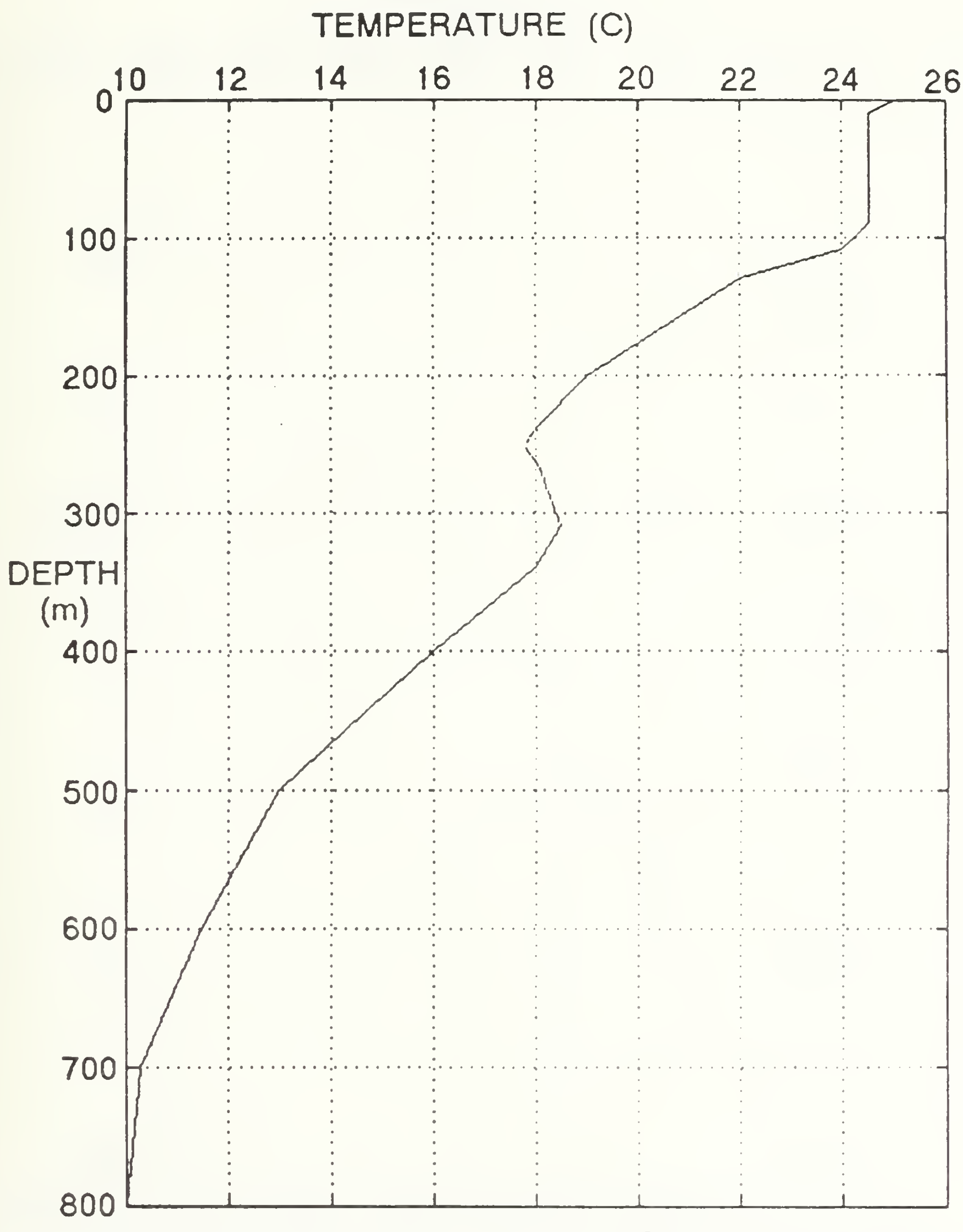
GULF OF OMAN
10 JANUARY 1993, 1000Z

25°01'N - 59°03'E

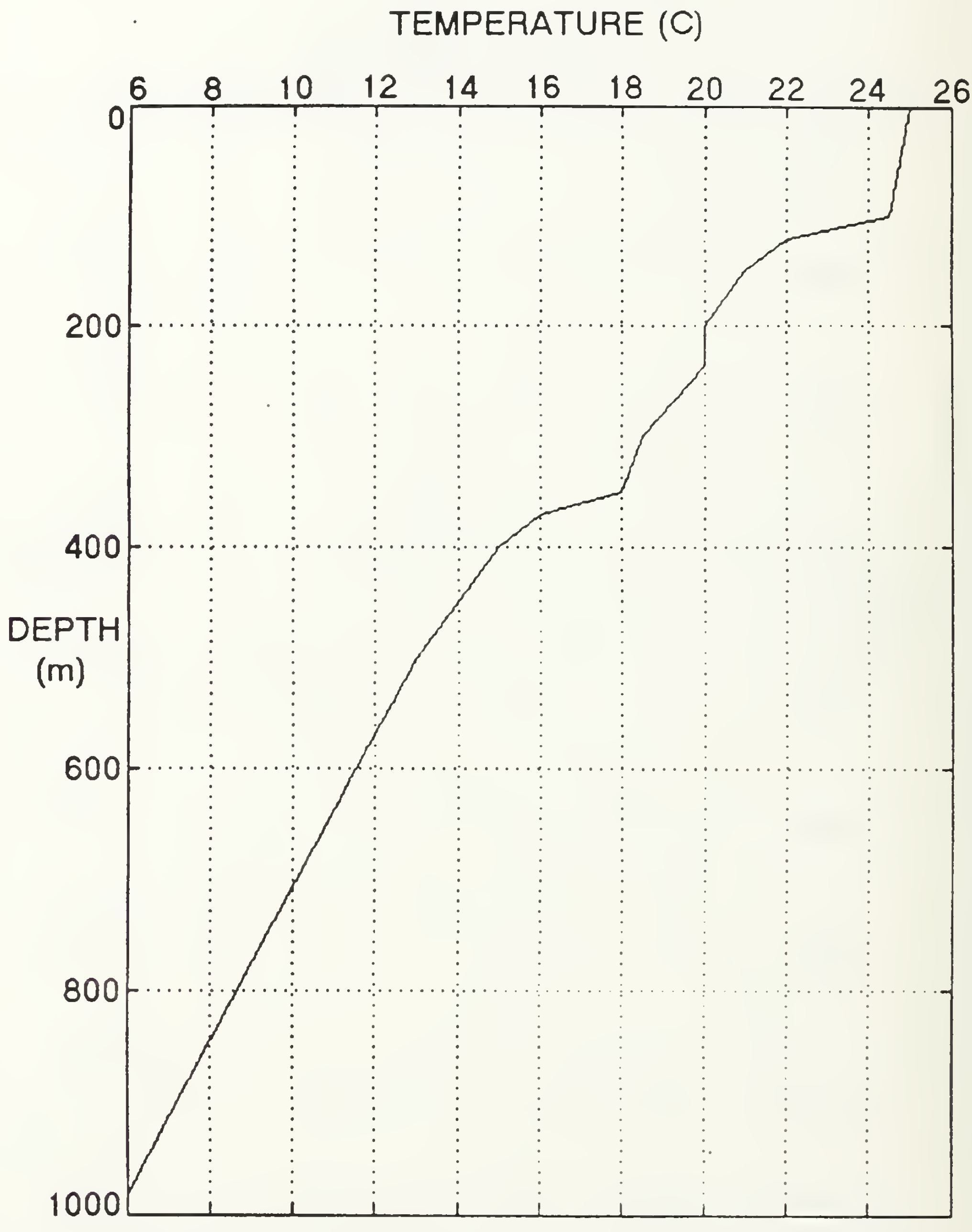




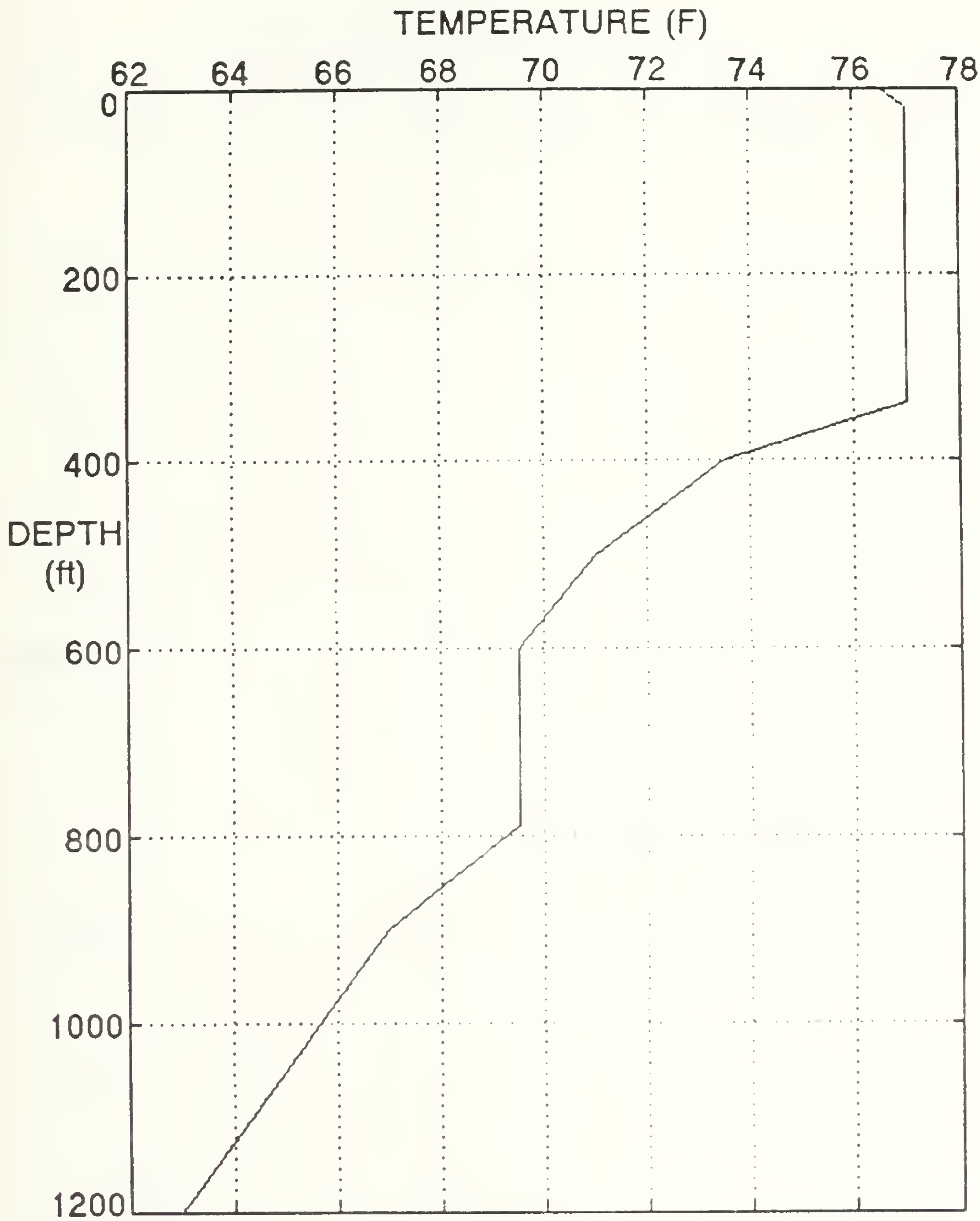
USNS Silas Bent XBT @ 24°44' - 60°37', 081025ZJAN93



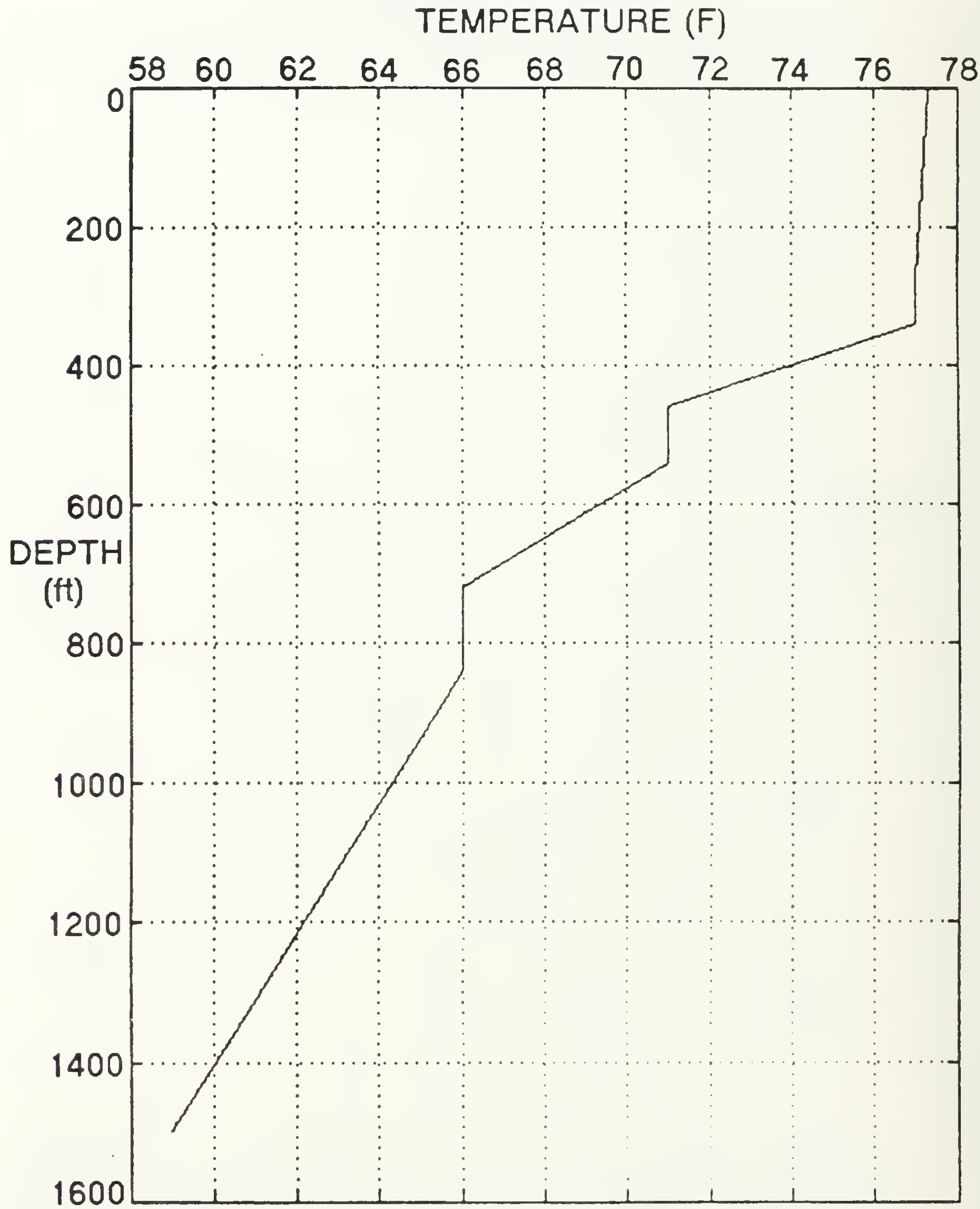
USNS Silas Bent XBT @ 24°59' - 58°59', 101400ZJAN93



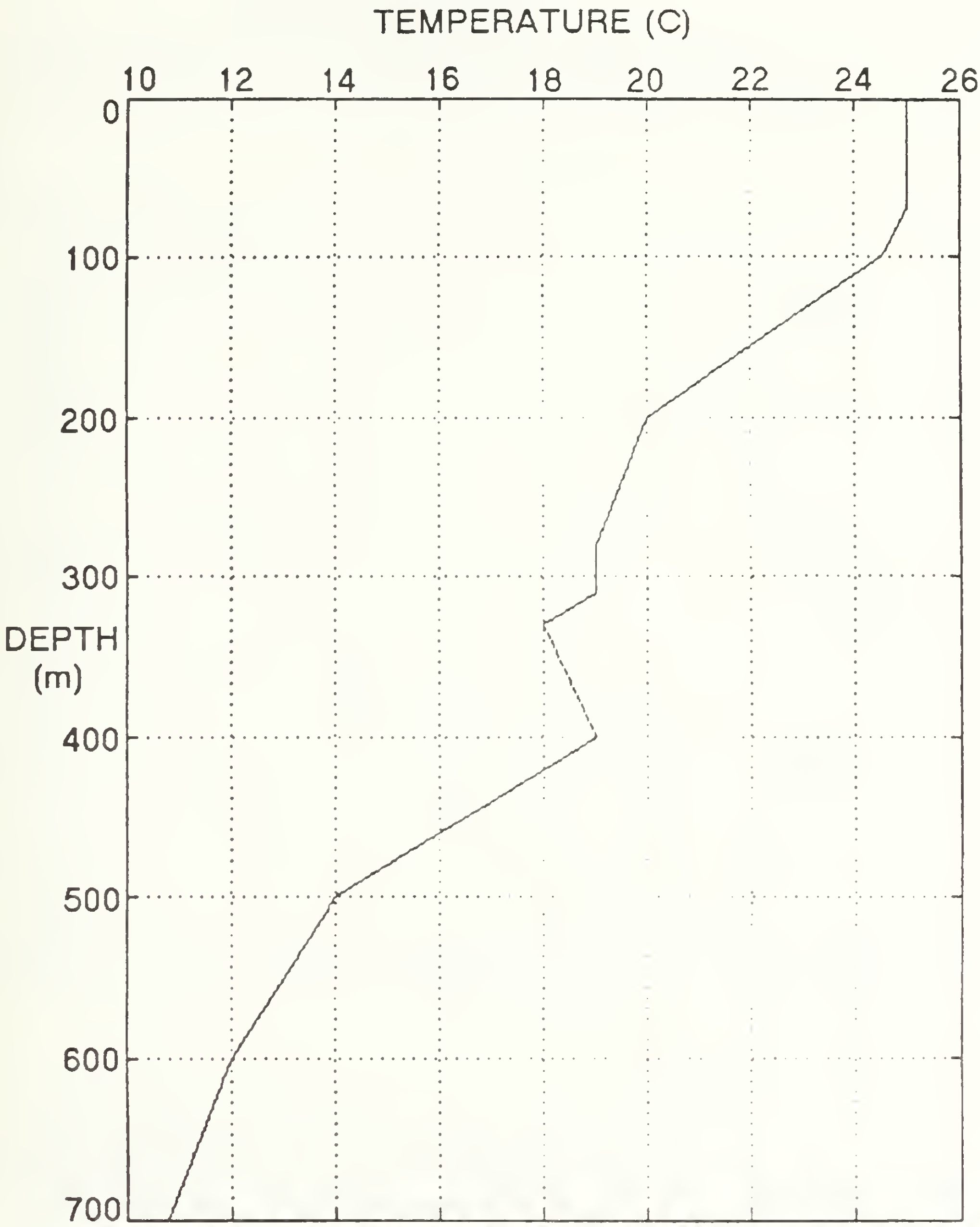
USNS Silas Bent @ 24°52' - 59°07', 101556ZJAN93



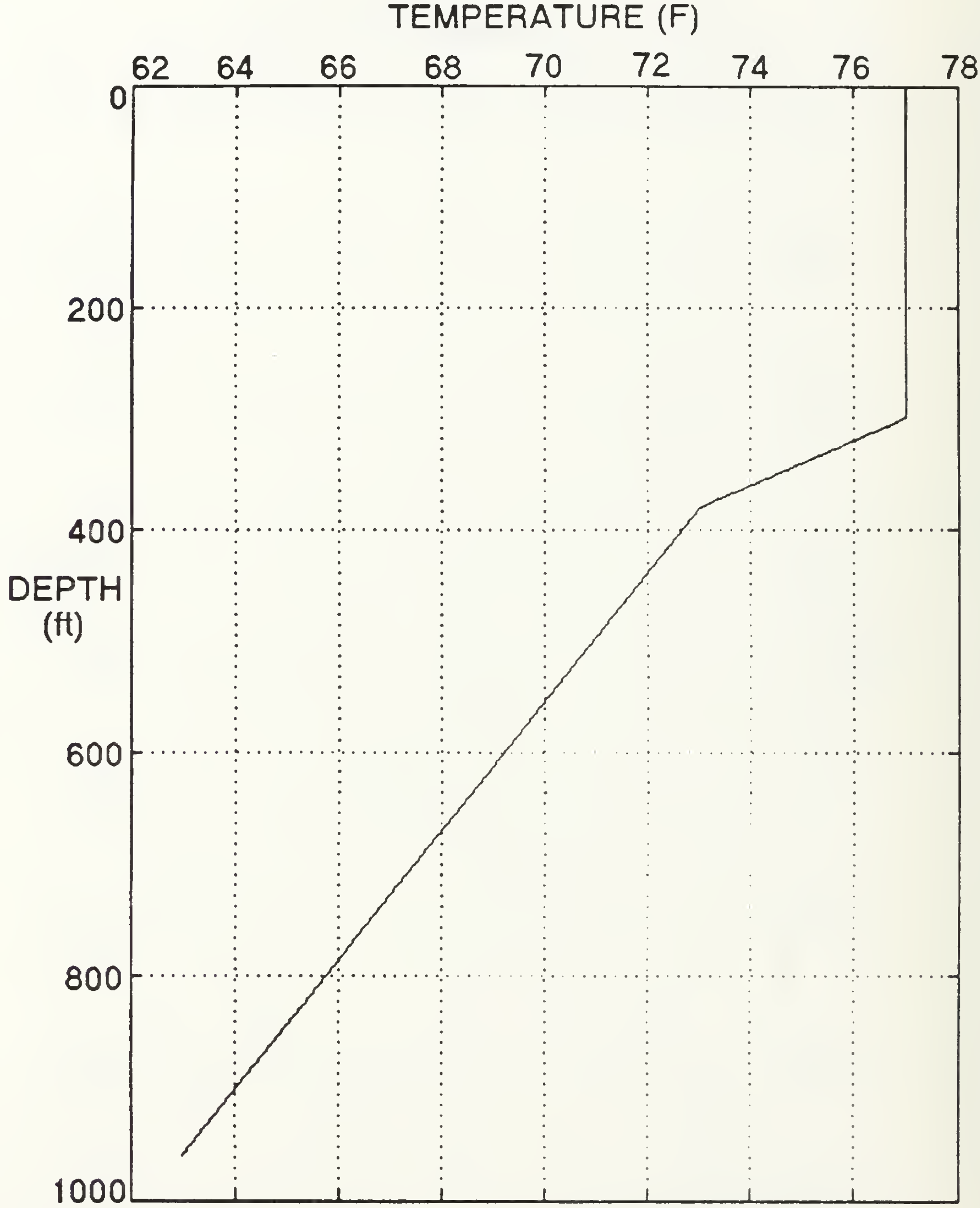
USS Stump XBT @ 24°52' - 59°09', 101629Z93



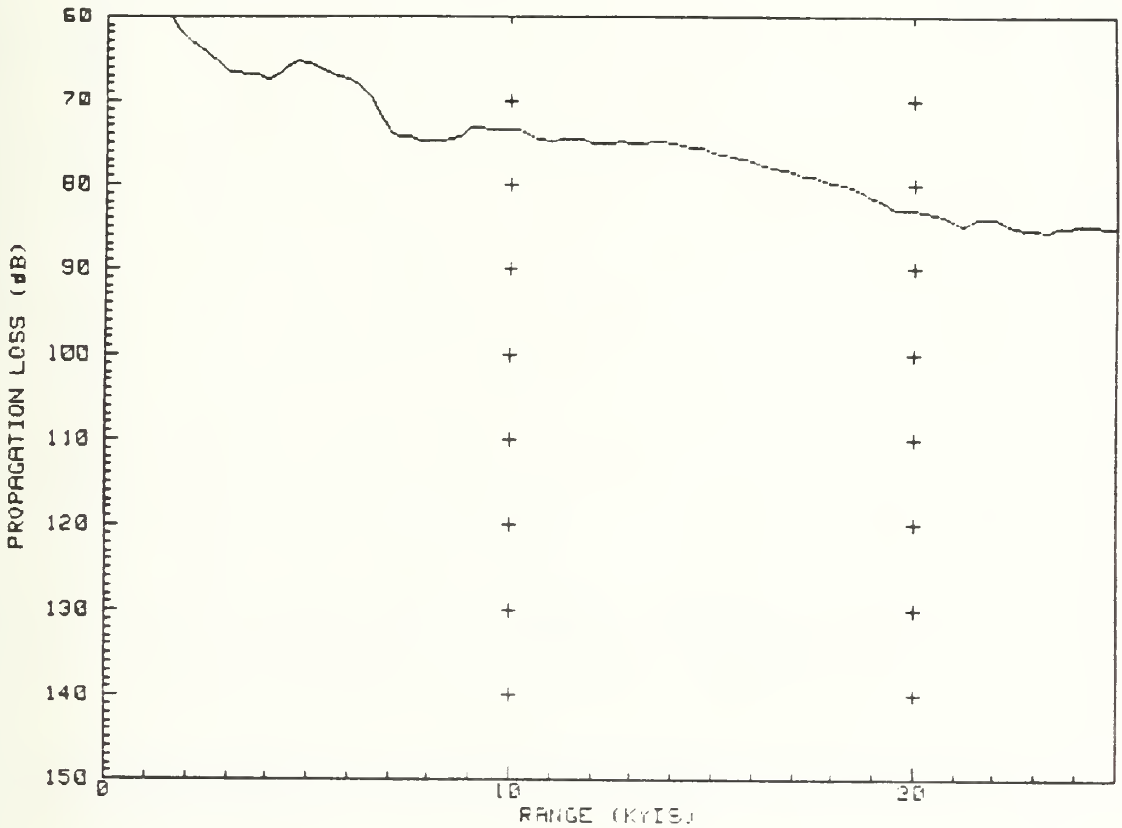
USS Stump XBT @ 24°46' - 59°00', 101729ZJAN93



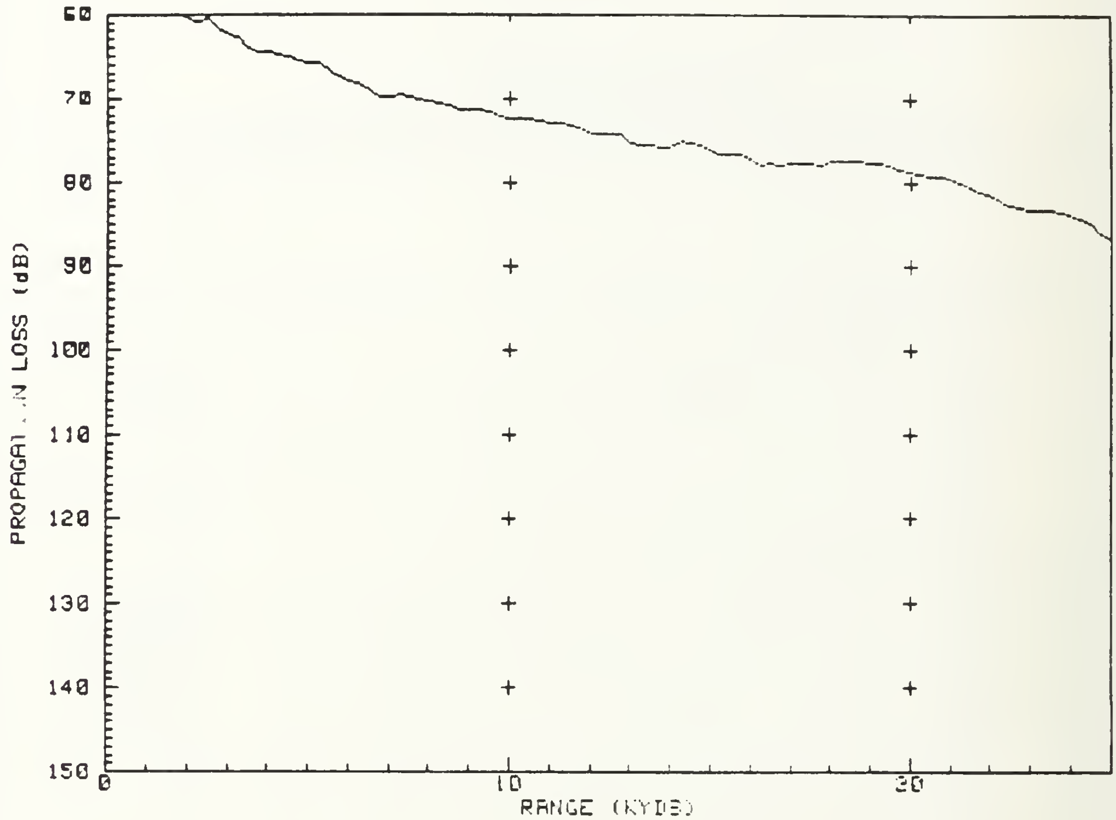
USNS Silas Bent XBT @ $24^{O}44'$ - $59^{O}00'$, 101803ZJAN93



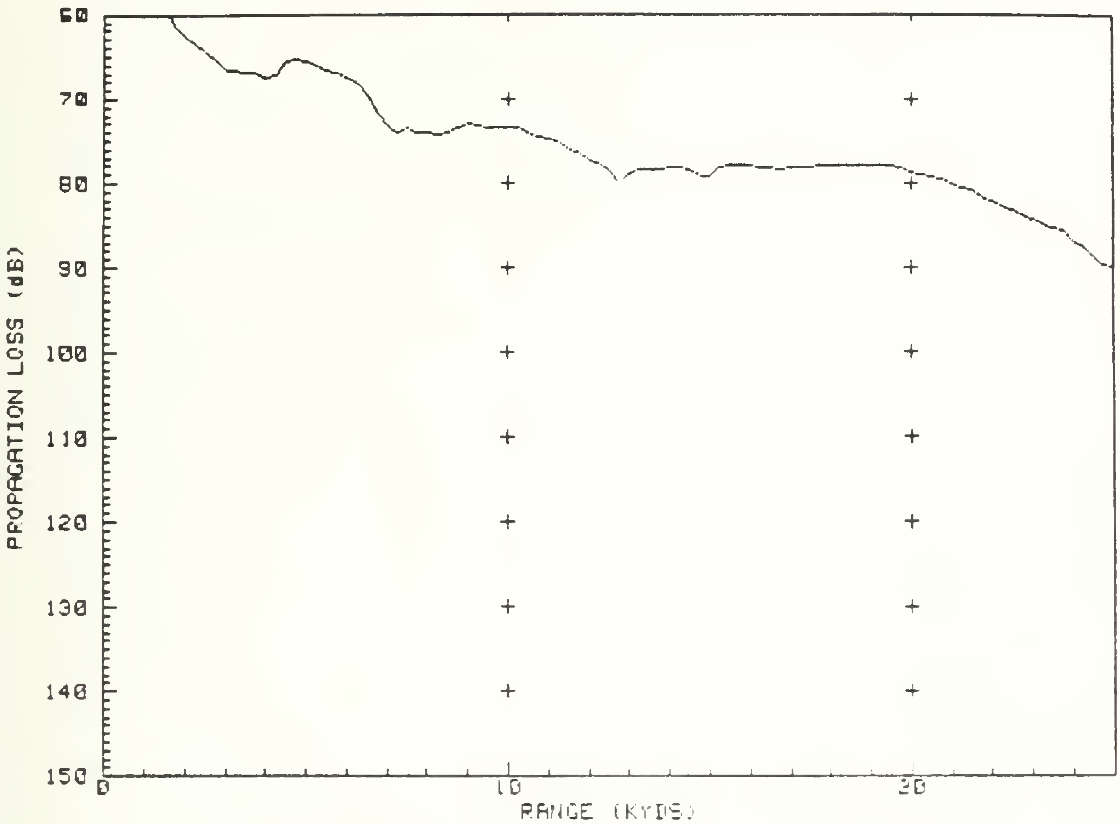
USS Stump XBT @ 24°40' - 58°58', 101825ZJAN93



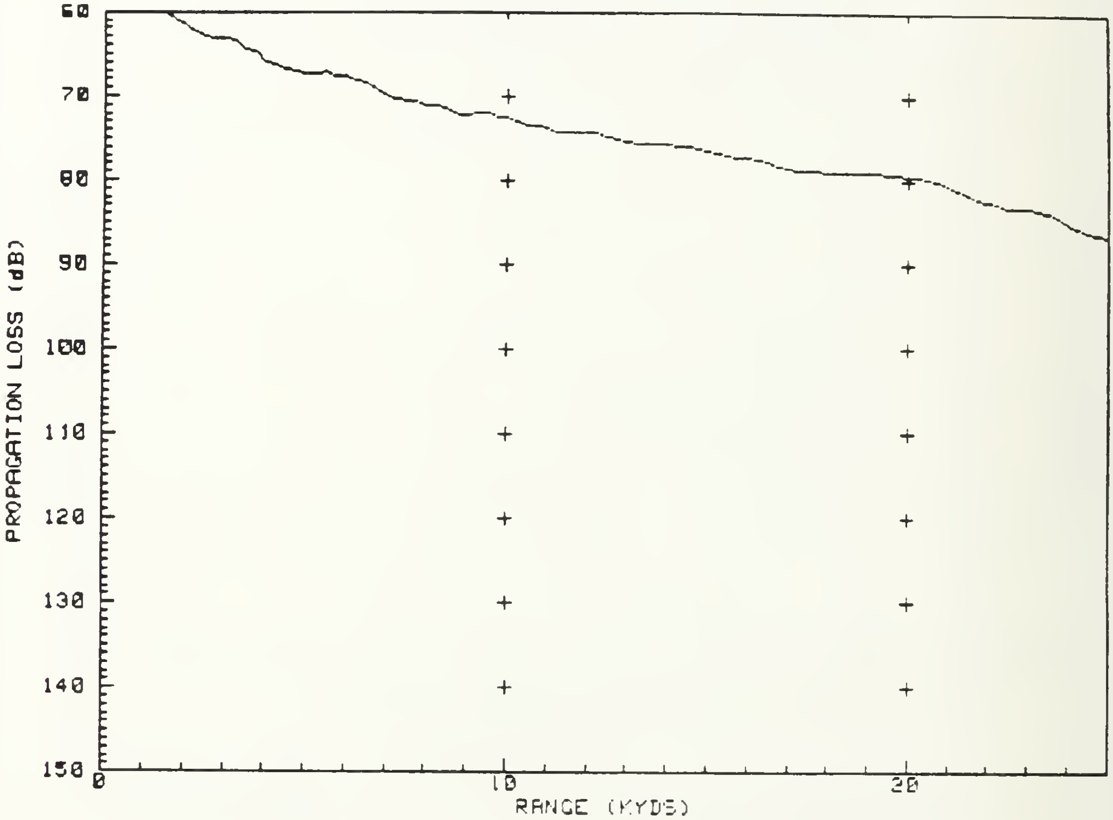
Range Independent (RI) Plot for Event 08117, Run 1, 60'R.
The RI prediction was 5 to 10 dB higher loss than the measured data.
The RI prediction was 3 to 5 dB higher loss than MAPS' prediction.



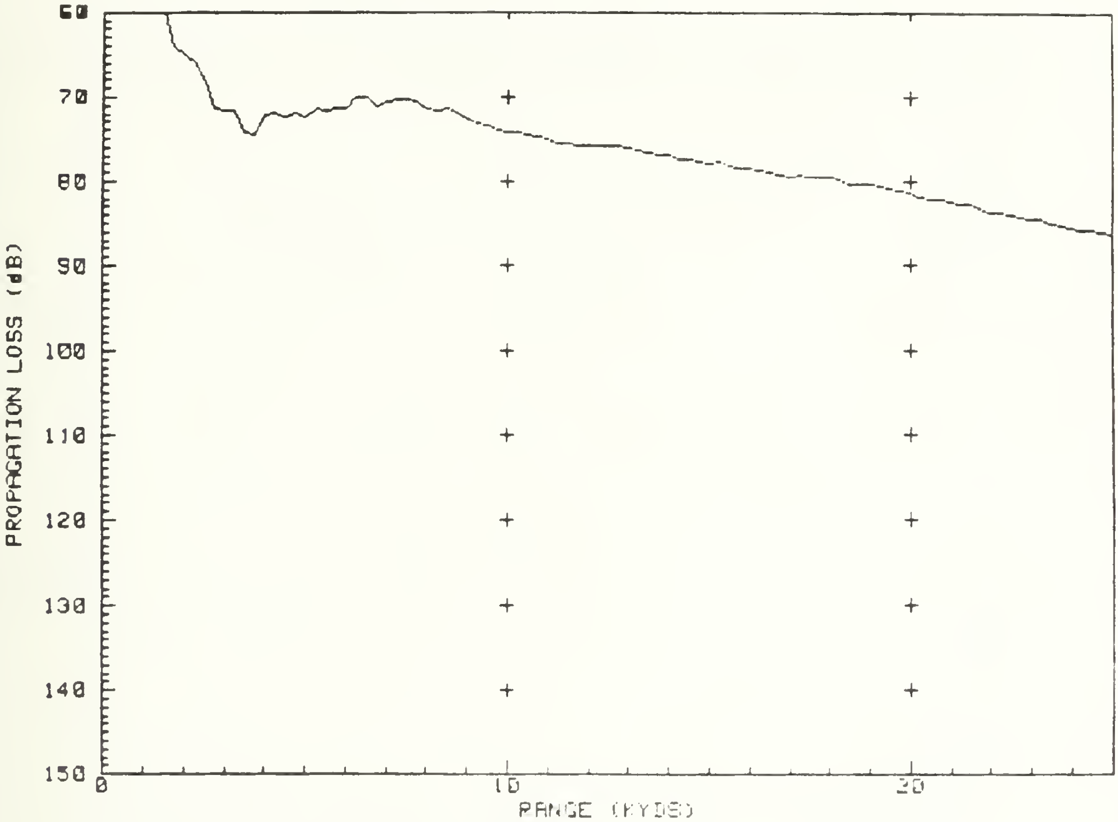
Range Independent (RI) Plot for Event 08117, Run 2, 25'R.
The RI prediction was 3 to 5 dB lower loss than the measured data.
The RI prediction and MAPS were almost identical.



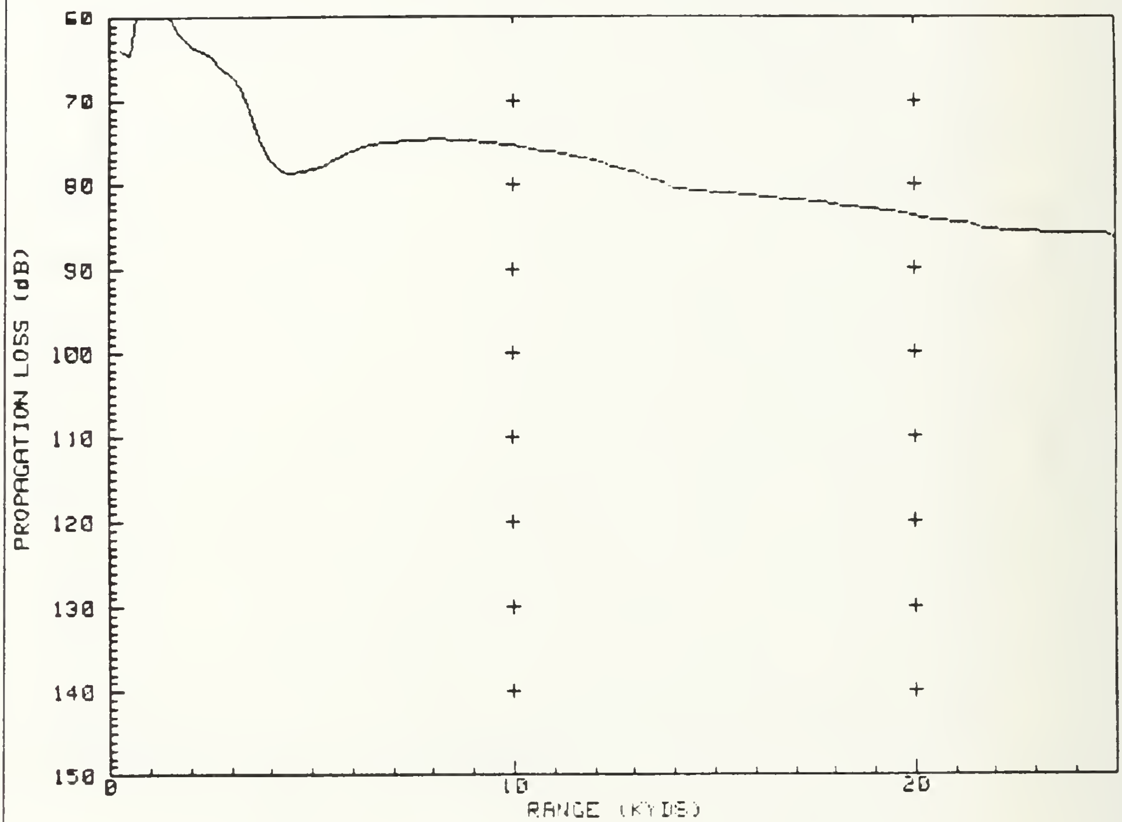
Range Independent (RI) Plot for Event 08117, Run 2, 60'R.
The RI prediction was 5 to 10 dB lower loss than the Measured Data.
The RI prediction (no bottom bounce) was not comparable to MAPS.



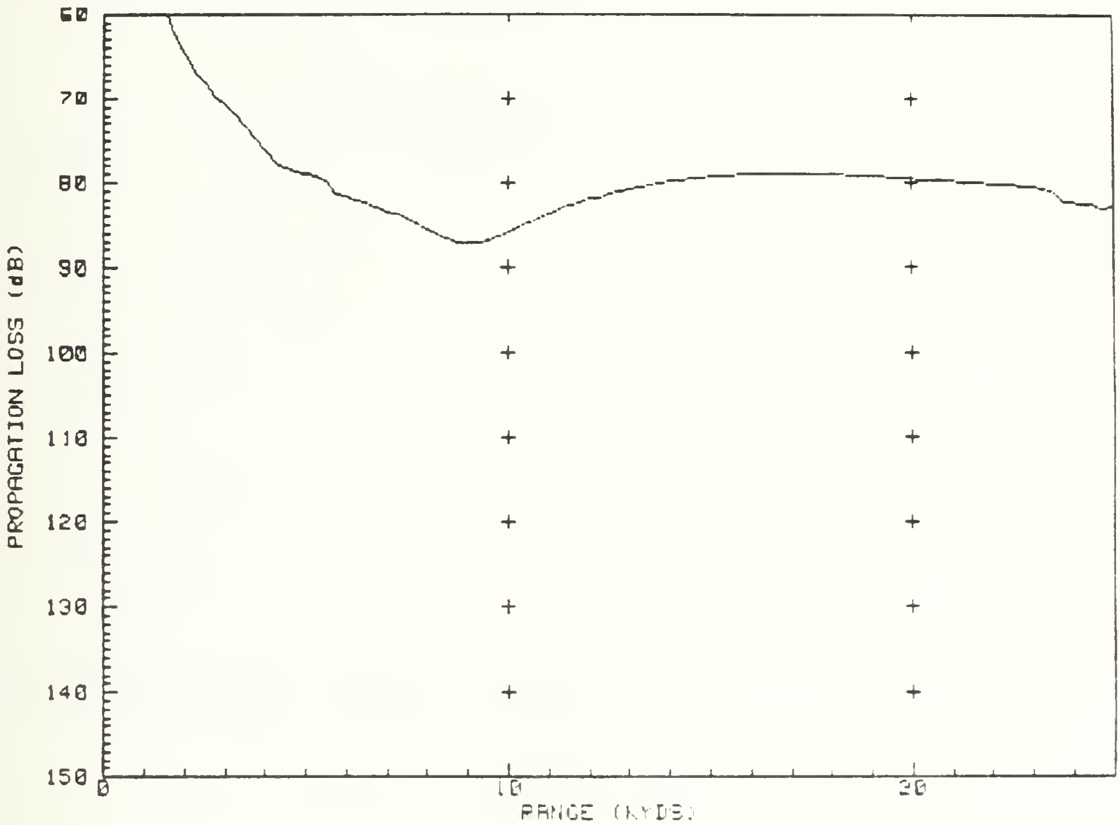
Range Independent (RI) Plot for Event 10115, Run 1, 25'R.
The RI prediction was not able to accurately reproduce
propagation losses predicted in the measured data.
The RI prediction (no bottom bounce) was not comparable to MAPS.



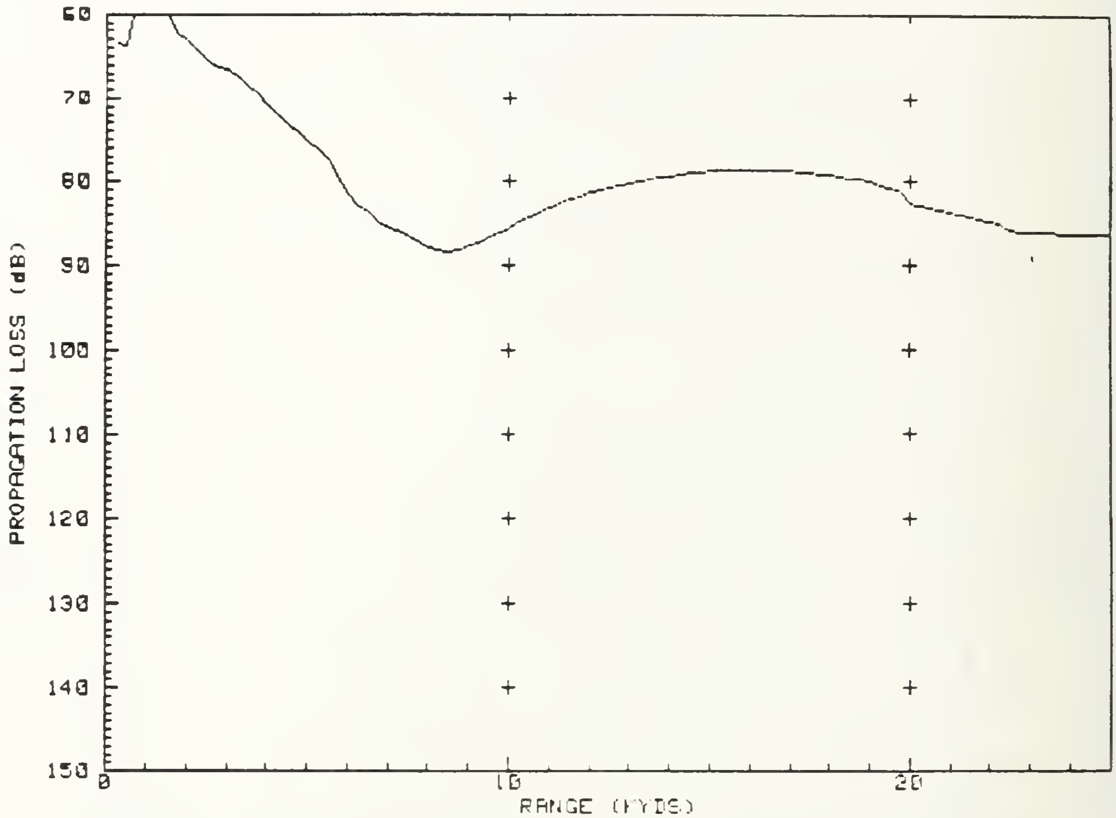
Range Independent (RI) Plot for Event 10115, Run 1, 60'R.
The RI prediction is 3 to 25 dB lower loss than the measured data.
The RI prediction (no bottom bounce)is not comparable to MAPS.



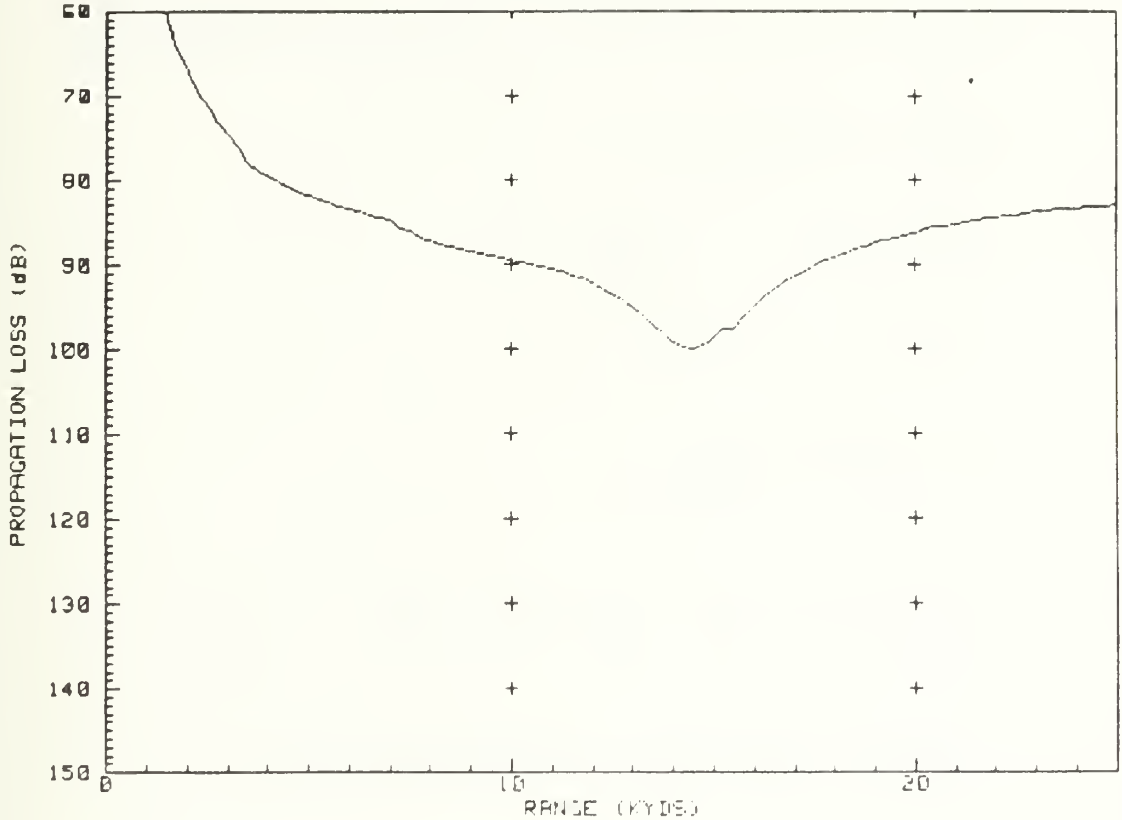
Range Independent (RI) Plot for Event 10115, Run 1, 300'R.
The RI prediction is 10 to 25 dB lower loss than the measured data.
The RI prediction was 20 dB lower loss than MAPS prediction.



Range Independent (RI) Plot for Event 10115, Run 2, 60'R.
The RI prediction does not reproduce the 17 kyd loss of sound energy.
The RI prediction was 20 dB lower loss than MAPS prediction.



Range Independent (RI) Plot for Event 10115, Run 2, 300'R.
The RI prediction was 5 to 20 dB lower loss than the measured data after the 10 kyd point.
The RI prediction was 25 dB lower loss than MAPS prediction.



Range Independent (RI) Plot for Event 10115, Run 3, 300'R.
The RI prediction was an accurate reproduction of the measured data.
The RI prediction closer than MAPS to measured data after 18 kyds.

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11. Dr Michael J. Pastore 1
128 Monte Vista Drive
Monterey, CA 93940

12. Mr Steve Dassinger 1
Naval Undersea Warfare Center Detachment
New London, CT 06320-5594